

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 |
|-------------------------------------|--|
| <input type="checkbox"/> | <input checked="" type="checkbox"/> The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> 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> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A description of all covariates tested |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> 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) |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
<i>Give P values as exact values whenever suitable.</i> |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> 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 on temperature and rainfall seasonality were extracted from a global climate database (0'30" × 0'30") for the 1970-2000 period from WorldClim Version 2.0 (<http://www.worldclim.org/>). Aridity was derived from Consortium for Spatial Information (CGIAR-CSI) for the 1950-2000 period. Soil sand content were obtained from the HWSD database (resolution 1km). Data originally published as figures were extracted using Engauge Digitizer V4.1 (<http://digitizer.sourceforge.net/>). Plant traits of 212 woody species were compiled based on online plant traits databases such as BROT, PLANTS, Woody Plants Database (<http://woodyplants.cals.cornell.edu/home>), TRY database.

Data analysis

The random effect model and meta-regressions was performed in the "metafor" package, all the figures were created using "ggplot2", "plotbiome" and "ggmap" in R version 4.0.379. SEM analyses were performed using SPSS AMOS 22 (IBM, Chicago, IL, USA) software.

The code used in the meta-analysis is available at ###

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](#)

All the materials, raw data, and protocols used in the article are available upon request and without restriction. The meta-analysis database is now deposited and available in Figshare repository (<https://doi.org/10.6084/m9.figshare.19915300.v1>).

Human research participants

Policy information about [studies involving human research participants and Sex and Gender in Research](#).

Reporting on sex and gender	<input type="text" value="This study did not involve any data on sex and gender."/>
Population characteristics	<input type="text" value="This study did not involve any data on population characteristics."/>
Recruitment	<input type="text" value="This study did not involve any data on recruitment."/>
Ethics oversight	<input type="text" value="This study did not involve any data on ethics oversight."/>

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](https://www.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	<input type="text" value="In this study, we used a meta-analytical approach by systematically searching the published literature on woody encroachment and woody removal. We totally compiled 12,344 records on the ecological impact of woody encroachment and removal (including mean, at least two replicates, standardized deviation) from 520 studies on woody encroachment and removal. We conducted the data analysis following a rigorous procedure on meta-analysis: 1) log response ratio was used to assess the ecological effect of woody encroachment and removal; 2) random-effect model was used to calculate the estimated effect size, with variance matrix included as the variance to account for the shared control, and the two random factors (i.e., a unique ID for each reference, the order of the data within the data file) included as random effects to account for the non-independence of data collected from same study and residuals of each data within the sample size; 3) publication bias of the database was examined using funnel plots, Egger regression and 'trim and fill' approaches; 4) linear and nonlinear regressions were fitted between the estimated mean effect size (LnRR) of the ecosystem response and the encroachment stages (woody coverage) and time since removal, respectively to explore how ecosystem response vary as the encroached stages and time since removal changes; 5) Structural Equation Modelling was used to explore the direct and indirect effects of environmental conditions, treatment, and encroachment signature on the effectiveness of woody plant removal after accounting for the effect of spatial locations."/>
Research sample	<input type="text" value="Research sample in this study is the impact of woody plant encroachment and woody plant removal on ecosystem structure, function and composition. Ecosystem structural attributes included those representing plant architecture or spatial distribution of the plant community, such as plant cover, density, patch shape and size. Measures depicting ecosystem processes such as production (e.g., biomass), hydrological processes (e.g., runoff, infiltration, soil erosion) and nutrient cycling (e.g., soil nutrients, plant nutrients) were included as ecosystem functional attributes. Ecosystem compositional attributes comprised variables indicating the variety of species including species diversity, richness and abundance."/>
Sampling strategy	<input type="text" value="This study is a meta-analysis in which the dataset was compiled based on published studies. We totally compiled 12,344 records on the ecological impact of woody encroachment and removal from 520 studies on woody encroachment and removal across all the continents. The ecological attributes involved in the analyses had at least 60 data points. Overall, the sample size is sufficient to support the results performed in the study."/>
Data collection	<input type="text" value="For each publication, we recorded the basic geographical information of the study, land use history, the identity of the dominant encroached or removed woody species, and the mean, replicates and standard deviation of the ecosystem responses that were assessed on woody plant encroached (treatment) and not encroached (control) or woody plant removal (treatment) and retention."/>

(control) plots for the encroachment and removal database, respectively. Data on temperature and rainfall seasonality were extracted from a global climate database (0'30" x 0'30") for the 1970-2000 period from WorldClim Version 2.0 (<http://www.worldclim.org/>). Aridity was derived from Consortium for Spatial Information (CGIAR-CSI) for the 1950-2000 period. Soil sand content were obtained from the HWSD database (resolution 1km)⁶⁸. Data originally published as figures were extracted using Engauge Digitizer V4.1 (<http://digitizer.sourceforge.net/>). Plant traits of 212 woody species were compiled based on online plant traits databases such as BROT69, PLANTS70, Woody Plants Database (<http://woodyplants.cals.cornell.edu/home>), TRY database.

Timing and spatial scale	Timing: 1950-2021 period, literature searched on 15 September 2021. Spatial scale: Studies were distributed globally across all continents except Antarctica, and covering a wide variety of biomes
Data exclusions	In this meta-analysis, published papers were only included in our database if they met the following a priori criteria: (i) the study was conducted under natural field conditions (greenhouse or growth chamber studies, as well as studies using cultivated plants, were not considered), (ii) the results were quantitative and therefore analysable, and (iii) the variables were collected strictly in plots encroached and without woody vegetation for the woody plant encroachment studies or in plot with woody plant removed and woody plant retained for the woody plant removal studies located in the same geographical area (hereafter encroached and removed plots as treatment, plots without woody plant and woody retained plots as control). This allowed us to be certain that any effects observed at each study could be attributed to the effects of encroachment or removal, and not to variation in climatic or soil type between the treatment and control plots. (iv) studies were included when the impacts resulted only from woody plant encroachment/invasion or woody plant removal rather than the invasion or removal of other plant species. In some studies, many exotic plant species rather than only woody species was invaded in the ecosystem or all the understorey vegetation was removed instead of only removing woody plants, so these studies were excluded; (v) studies were included only if the reported data were representative of whole grassland and encroached plots for encroachment studies and were representative of land that dominated by woody plants and removed plots. Studies that evaluated the effects of woody vegetation or without woody plant on the response variables considered at the microsite level (e.g. comparing the effects of shrub vs. grass canopies on vegetation or soil attributes within the same site) were not considered. For woody plant removal database, studies with shared controls (multiple treatments with one control) were included only if these treatments were conducted in the same geographical area and during the same period. Studies comparing before and after treatment with no specific control treatment were not regarded as paired and were therefore excluded from the database.
Reproducibility	The results of this study can be reproducibility based on the dataset and code that available in Figshare (https://doi.org/10.6084/m9.figshare.19915300.v1) and ###.
Randomization	This study is a meta-analysis and data in this study was allocated into separate ecological attribute group, which do not involve randomization.
Blinding	This study is a meta-analysis which used the data collected from published studies. Therefore blinding is not applicable for this study.
Did the study involve field work?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> 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
<input checked="" type="checkbox"/>	<input type="checkbox"/> Antibodies
<input checked="" type="checkbox"/>	<input type="checkbox"/> Eukaryotic cell lines
<input checked="" type="checkbox"/>	<input type="checkbox"/> Palaeontology and archaeology
<input checked="" type="checkbox"/>	<input type="checkbox"/> Animals and other organisms
<input checked="" type="checkbox"/>	<input type="checkbox"/> Clinical data
<input checked="" type="checkbox"/>	<input type="checkbox"/> Dual use research of concern

Methods

n/a	Involved in the study
<input checked="" type="checkbox"/>	<input type="checkbox"/> ChIP-seq
<input checked="" type="checkbox"/>	<input type="checkbox"/> Flow cytometry
<input checked="" type="checkbox"/>	<input type="checkbox"/> MRI-based neuroimaging