

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
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☐ | ☒ | 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
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ | 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 | Satellite remote sensing data were accessed from GEE and no softwares were used to access field measurements of data used in this study. |
| Data analysis | Analyses were performed using R version 4.2.0 (2022) and with the following packages: caret, gbm, tidyverse, lme4, and ggplot2 as well as GEE. Image segmentation was processed with the SNIC algorithm while the the InceptionTime architecture deep learning approach was used for prediction. The relevant codes for data processing can be accessed from: https://github.com/surxuxu/Boreal-forest-diversity |

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](#)

Boreal tree species diversity data used to conduct analyses for the manuscript are available at <https://figshare.com/s/a7cac743013cf536caaf>.
The Landsat surface reflectance data used in this study are freely available and can be obtained from <https://earthengine.google.com/>. ECMWF Reanalysis v5 (ERA5)

climatic data are available from <https://www.ecmwf.int/en/forecasts/dataset/ecmwf-reanalysis-v5>. RegridDED Harmonized World Soil Database v.1.2 are available from <https://www.fao.org/soils-portal/data-hub>. Terra and Aqua combined MCD64A1 Version 6 Burned Area data are available from <https://lpdaac.usgs.gov/products/mcd64a1v006/>. Gridded Population of World Version 4 (GPWv4) are available from <https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-count-rev11>. ASTER Global Elevation Model are available from <https://asterweb.jpl.nasa.gov/gdem.asp>. The AGB_1(aboveground biomass) data are available from <https://doi.org/10.3390/rs9050457>, and the AGB_2 data are available from <https://doi.org/10.1126/sciadv.abe9829>. MODIS MOD17A3HGF Version 6.1 product are available from <https://lpdaac.usgs.gov/products/mod17a3hgf061/>. VOD Ku-band data are available from <https://doi.org/10.5281/zenodo.2575599>.

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](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	This study developed a novel approach to map continuous spatial distribution of tree species diversity and explored the associated impact on boreal ecosystem productivity and stability
Research sample	We collected samples including 5,127 field observations of a total of 188,639 trees divided into 254 tree species from six countries (Supplementary Table 5) and satellite-based gridded datasets.
Sampling strategy	NA
Data collection	Plot based data are available referring to Supplementary Table 5 and the satellite data are open access from Google Earth Engine.
Timing and spatial scale	Data covering the boreal forest ecosystem spanning 2000-2020 are used.
Data exclusions	Satellite pixels with poor quality.
Reproducibility	All results are being processed many time and the data and code are available from https://github.com/surxuxu/Boreal-forest-diversity
Randomization	NA
Blinding	NA

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 | Involvement 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 | Involvement in the study |
| ☒ | ☐ ChIP-seq |
| ☒ | ☐ Flow cytometry |
| ☒ | ☐ MRI-based neuroimaging |