

## 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 There is no software or code for data collection.

Data analysis The code for plotting and data analysis has been included in a CodeOcean capsule and is available at <https://codeocean.com/signup/nature?token=520ceee98b824bb2abbbbeac20c740816>

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 used in this study are available as following: the variables from the ERA5-Land dataset can be accessed at <https://cds.climate.copernicus.eu>, the hPET dataset is available at <https://doi.org/10.5523/bris.qb8ujazzda0s2aykkv0oq0ctp>, the PKU GIMMS NDVI product is available at <https://doi.org/10.5281/zenodo.8253971>, the GLOBMAP LAI product can be found at <http://www.globalmapping.org/globalLAI>, the GOSIF dataset is available at <http://>

globalecology.unh.edu, the MCD12Q2 data is available at <https://lpdaac.usgs.gov>, the 2015 global fine-scale forest composition map can be accessed at <https://doi.org/10.5281/zenodo.5879022>, and the GLC\_FCS30D dataset is available at <https://doi.org/10.5281/zenodo.8239305>. The derived variables generated in this study have been deposited in the Figshare database at <https://doi.org/10.6084/m9.figshare.28351715>.

## 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

Reporting on race, ethnicity, or other socially relevant groupings

Population characteristics

Recruitment

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://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 analyzes the spatiotemporal patterns of flash drought (FD) events and their characteristics (onset rate, peak stress, and stress duration) worldwide from 1982 to 2022. After that, this study explores the responses of intact and managed forests to FD events and investigates the synergistic effects of forest management practices, FD characteristics, background climate, and meteorological anomalies during FD events.
Research sample	Biophysical parameters of forests (NDVI, LAI, and SIF) during flash drought (FD) events from 1982 to 2022 worldwide were used to analyze forest responses to FD events. Additionally, the corresponding grid-based FD characteristics (onset rate, peak stress, and stress duration), meteorological anomalies (precipitation and temperature anomalies) during FD events, background climate (mean annual temperature and precipitation), and forest management practices (intact and managed forest) were used as regulating factors to investigate the synergistic effects.
Sampling strategy	This study did not use a sampling method but instead treated all data that met the criteria as analysis samples, with a total of 3,706,691 samples.
Data collection	The data used in this study are all open access as follows: the variables from the ERA5-Land dataset can be accessed at <a href="https://cds.climate.copernicus.eu">https://cds.climate.copernicus.eu</a> , the hPET dataset is available at <a href="https://doi.org/10.5523/bris.qb8ujazzda0s2aykkv0oq0ctp">https://doi.org/10.5523/bris.qb8ujazzda0s2aykkv0oq0ctp</a> , the PKU GIMMS NDVI product is available at <a href="https://doi.org/10.5281/zenodo.8253971">https://doi.org/10.5281/zenodo.8253971</a> , the GLOBMAP LAI product can be found at <a href="http://www.globalmapping.org/globalLAI">http://www.globalmapping.org/globalLAI</a> , the GOSIF dataset is available at <a href="http://globalecology.unh.edu">http://globalecology.unh.edu</a> , the MCD12Q2 data is available at <a href="https://lpdaac.usgs.gov">https://lpdaac.usgs.gov</a> , the 2015 global fine-scale forest composition map can be accessed at <a href="https://doi.org/10.5281/zenodo.5879022">https://doi.org/10.5281/zenodo.5879022</a> , and the GLC_FCS30D dataset is available at <a href="https://doi.org/10.5281/zenodo.8239305">https://doi.org/10.5281/zenodo.8239305</a> . Jianzhuang Pang collected the required data and processed it as described in the Methods section.
Timing and spatial scale	<p>The timing and spatial scale of the data used in this study are as follows. With the exception of the data used to confirm forest types (2015 global fine-scale forest composition map and GLC_FCS30D), all other data were resampled to a daily scale using linear interpolation and to a 0.1° grid using the nearest-neighbor method, while maintaining the original time span. For forest types, this study retained only the 0.1° grids where a single forest type covered more than 50% of the grid area and excluded those with more than 50% change in forest area. Considering that the LAI and SIF data are primarily used for supplementary validation of the NDVI results, it is acceptable that they do not align with the study period of this research (1982–2022).</p> <ol style="list-style-type: none"> <li>1. ERA5-Land (Precipitation and Temperature): 1982~2022, 0.1°, daily.</li> <li>2. hPET (Potential evapotranspiration): 1982~2022, 0.1°, daily.</li> <li>3. PKU GIMMS NDVI (Normalized Difference Vegetation Index): 1982~2022, 1/12°, 15-days.</li> <li>4. GLOBMAP LAI product (Leaf Area Index): 1982~2019, 500m, 8-days.</li> <li>5. GOSIF (Solar-induced chlorophyll fluorescence): 2000~2022, 0.05°, 8-days.</li> <li>6. 2015 global fine-scale forest composition map (Forest types): 2015, 100m, single map</li> </ol>

7. GLC\_FCS30D (Land cover): 1985~2022, 30m, 26 time steps (maps were updated every 5 years before 2000 and annually after 2000)

## Data exclusions

1. To exclude the interference of non-growing seasons, this study retained only the flash drought events occurring during the growing season. The growing season was defined from the annual greenup date to the dormancy date using the MODIS Land Cover Dynamics product (MCD12Q2), and the multi-year average from 2002 to 2022 was used to reduce the influence of interannual fluctuations.

2. To distinguish flash drought events from conventional or long-term droughts and exclude insignificant short-term events, FD events were defined as having a duration of 6 to 18 pentads.

3. To distinguish the effects of logging and FD events on forest dynamics, FD events with at least five consecutive pentads where  $\Delta NDVI < -1$  before the event were excluded when analyzing the responses of forest management practices involving logging (such as naturally regenerating forests with signs of management and plantation forests with rotation periods of up to 15 years).

## Reproducibility

This study is based on open access datasets and does not involve any experiments.

## Randomization

In this study, all samples were used for analyses of statistical characteristics, trends, and attribution, without any grouping. Therefore, randomization of the samples was not involved.

## Blinding

This study does not involve blinding, as all data are derived from observations or reanalysis and are not influenced by expectations or prior knowledge.

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

### Methods

- 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

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

### Plants

## Seed stocks

This study does not involve seed stocks.

## Novel plant genotypes

This study does not involve novel plant genotypes.

## Authentication

This study does not involve authentication.