

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 (<i>n</i>) 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. <i>F</i> , <i>t</i> , <i>r</i>) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> 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 <i>d</i> , Pearson's <i>r</i>), 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
Data analysis	bbduk.sh v38.18 bbnorm.sh v38.18 idba_ud v1.1.3 Maxbin v2.2.7 metaBAT2 v2.15 miga v1.3.8.3 dRep v3.4.3 CheckM v1.2.2 GTDB-tk v2.1.0 DRAM v1.4.6 CoverM v0.6.1 MicrobeCensus v1.1.0 Prodigal v2.6.3 PhyloPhlAn v3.0.67 sortMeRNA v4.3.4 MASH v1.1 fastANI v1.33

MMseqs2 v13.45111
 enveomics scripts (no version available)
 kofamscan (no version available)
 BLASTp v2.14.0
 mzCloud
 Classifyfire
 CMM-RT
 R v4.2.3

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 raw metagenomic sequences supporting this study are available in the NCBI BioProject repository (<http://ncbi.nlm.nih.gov/bioproject>) under the following accession numbers: PRJNA364951-PRJNA364992, PRJNA443580-PRJNA443616, PRJNA444884-PRJNA444890, PRJNA651484-PRJNA651504, PRJNA677007-PRJNA677020, and PRJNA697594-PRJNA697710 (see also Supplementary Table 4). MAGs analyzed in this manuscript were deposited in NCBI under BioProject PRJNA1084886 (see also Supplementary Table 1). Additionally, SPRUCE Whole Ecosystems Warming (WEW) Environmental Data is available at <https://doi.org/10.3334/CDIAC/spruce.032>, and SPRUCE Porewater Chemistry Data for Experimental Plots is available at <https://doi.org/10.3334/CDIAC/spruce.028>. All accompanying metadata generated in this study are provided in the Supplementary Data Files. Should any raw data files be needed in another format they are available from the corresponding author upon reasonable request.

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

NA

Reporting on race, ethnicity, or other socially relevant groupings

NA

Population characteristics

NA

Recruitment

NA

Ethics oversight

NA

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

The study aims to provide insights into the response of northern peatland microbial communities to climate drivers, specifically temperature and elevated CO₂. For this purpose we leverage the Spruce and Peatland Responses Under Changing Environments (SPRUCE), a whole-ecosystem warming experiment located in Northern Minnesota with 17 open-top enclosures that controls for temperature (ambient, +0, +2.25, +4.5, +6.75 and +9°C) and CO₂ (ambient and 900 ppm).

Research sample

Peat samples were collected from within the chambers at four depth layers (10-20, 40-50, 75-100 and 150-175 cm).

Sampling strategy	Peat samples were collected from 12 chambers with a serrated knife at the surface and a Russian corer at depth. The samples were separated into depth increments and six 0.35-g subsamples of homogenized peat from the 10-20 cm, 40-50 cm, 100-125 cm, and 150-175 cm depth increments were collected and immediately frozen.
Data collection	Samples were collected in June 2015 and 2016 and August 2018.
Timing and spatial scale	Given the uniqueness of the SPRUCE experiment, the destructive nature of peat sampling and the limited peat available within the chambers, only one peat core per chamber was permitted each year. Samples were collected during a few consecutive days in the months and years stated above.
Data exclusions	NA
Reproducibility	Given the uniqueness of the SPRUCE experiment, the destructive nature of peat sampling and the limited peat available within the chambers, only two biological replicates per warming treatment per year could be obtained (each warming treatment is applied to two distinct chambers). We analysed 3 years, to ensure our results are consistent over time.
Randomization	Samples were grouped based on predefined warming treatments (ambient, +0, +2.25, +4.5, +6.75 and +9°C) and depths (10-20, 40-50, 75-100 and 150-175 cm).
Blinding	No blinding was applied. Samples were grouped base on predefined characteristics, such as temperature treatment and year, that our research team had to know to choose the appropriate data analyses. Our conclusions are supported on quantitative data obtained by applying the same procedure to all samples as well as evidence from different sources. This approach minimizes the impact of subjective interpretations.

Did the study involve field work? ☒ Yes ☐ No

Field work, collection and transport

Field conditions	Field work was conducted during the growing period (summer). Environmental variables, including temperature, precipitation, water table elevation, among others, are measured daily and available in https://mnspruce.ornl.gov/datasets/public
Location	Sampling was performed in the SPRUCE experimental facilities located in the S1 Bog of the Marcell Experimental Forest, north of Grand Rapids, MN (47°30.4760N; 93°27.1620W).
Access & import/export	<i>Describe the efforts you have made to access habitats and to collect and import/export your samples in a responsible manner and in compliance with local, national and international laws, noting any permits that were obtained (give the name of the issuing authority, the date of issue, and any identifying information).</i>
Disturbance	To minimize the impact on the ecosystem within the enclosures, only one peat sample per year per enclosure was permitted.

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

Dual use research of concern

Policy information about [dual use research of concern](#)

Hazards

Could the accidental, deliberate or reckless misuse of agents or technologies generated in the work, or the application of information presented in the manuscript, pose a threat to:

No	Yes
☒	☐ Public health
☒	☐ National security
☒	☐ Crops and/or livestock
☒	☐ Ecosystems
☒	☐ Any other significant area

Experiments of concern

Does the work involve any of these experiments of concern:

No	Yes
☒	☐ Demonstrate how to render a vaccine ineffective
☒	☐ Confer resistance to therapeutically useful antibiotics or antiviral agents
☒	☐ Enhance the virulence of a pathogen or render a nonpathogen virulent
☒	☐ Increase transmissibility of a pathogen
☒	☐ Alter the host range of a pathogen
☒	☐ Enable evasion of diagnostic/detection modalities
☒	☐ Enable the weaponization of a biological agent or toxin
☒	☐ Any other potentially harmful combination of experiments and agents

Plants

Seed stocks	The Spruce and Peatland Responses Under Changing Environments (SPRUCE) is whole ecosystem warming experiment located in the ombrotrophic, acidic S1 Bog of the Marcell Experimental Forest, north of Grand Rapids, MN (47°30.4760N; 93°27.1620W). The experiment consists of 17 open-top chambers that control the peat and air temperature (ambient, +0, +2.25, +4.5, +6.75 and +9°C) as well as atmospheric CO ₂ concentration (ambient and 900 ppm). Peat cores were collected in June of 2015 and 2016 and August of 2018 from the hollows of each of the 10 whole-ecosystem warming chambers with a serrated knife at the surface and a Russian corer at depth. The cores were separated into depth increments and six 0.35-g subsamples of homogenized peat from the 10-20 cm, 40-50 cm, 100-125 cm, and 150-175 cm depth increments were collected.
Novel plant genotypes	
Authentication	