

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

Data analysis

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](#)

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	Not relevant for the study.
Reporting on race, ethnicity, or other socially relevant groupings	Not relevant for the study.
Population characteristics	Not relevant for the study.
Recruitment	Not relevant for the study.
Ethics oversight	Not relevant for the study.

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	This study provides a comprehensive analysis of the divergent fates of canopy (CAN) and understory (UAN) N addition treatments in a young secondary forest. We found that above canopy and understory nitrogen additions lead to divergent spatio-temporal nitrogen retention patterns in a temperate forest.
Research sample	Soil (0-10, 10-20 and 20-40 cm) and plant (trees, shrubs, herbs, litter and roots) samples were collected from four 15N tracer addition treatment (control: water, CAN-15NH ₄ ⁺ , UAN-15NH ₄ ⁺ , CAN-15NO ₃ ⁻ and UAN-15NO ₃ ⁻) with three replicates of each level. From each plot, four soil samples were collected randomly from each plot. Each soil core was separated into 0-10 cm, 10-20 cm and 20-40 cm layer. Three 30 cm × 30 cm subplots were randomly selected to collect understory layer (litter, herbs, and shrubs) samples, which were then separately pooled into composite samples. Live fine roots were collected from three independent selected soil blocks (20 cm × 20 cm × 20 cm) randomly excavated within per subplot and pooled into one composite sample. Foliage and branches from the upper and middle canopy that had been exposed to the sun were collected using a 15 m pole pruner (height >10 m). From each tree, a mixture of foliage was taken from two to three sunny branches in these canopy positions. Branches were also collected. Wood cores were collected using an increment borer from trees with DBH > 5 cm. 15N abundance and TN (and TC) concentrations were measured using an elemental analyzer-isotope ratio mass spectrometry at the Institute of Applied Ecology (Elementar Analysen Systeme GmbH; IsoPrime100, IsoPrime Ltd).
Sampling strategy	Soil samples were collected after litter removal. four soil samples were collected randomly from each plot. Each soil core was separated into 0-10 cm, 10-20 cm and 20-40 cm layer; the 10-20 cm and 20-40 cm layer was only collected at 120 and 365 days. Soil from the four cores at the same depth within a subplot was composited into one sample per layer, yielding three composite soil samples per subplot. We sieved soil through a 2 mm sieve to remove roots and coarse fragments and then left it to dry naturally for elemental analysis. Three 30 cm × 30 cm subplots were selected to collect samples of the understory layer (litter, herbs and shrubs). These were then pooled into composite samples. Live fine roots were collected from three 20 cm × 20 cm × 20 cm soil blocks within each subplot and pooled into one composite sample. Foliage and branches from the upper and middle canopy that had been exposed to the sun were collected using a 15 m pole pruner (height >10 m). From each tree, a mixture of foliage was taken from two to three sunny branches in these canopy positions. Branches were also collected. Wood cores were collected from trees with DBH > 5 cm using an increment borer. All plant samples were dried to a constant weight at 65° in an electrothermal constant temperature drying oven for biomass calculations and elemental analysis.
Data collection	15N abundance and TN (and TC) concentrations using an elemental analyzer-isotope ratio mass spectrometry at the Institute of Applied Ecology (Elementar Analysen Systeme GmbH; IsoPrime100, IsoPrime Ltd). Wet and dry deposition samples were collected using an APS3B automatic sampler (Changsha Xianglan Scientific Instrument Co., Ltd. China), which also recorded precipitation data.
Timing and spatial scale	The field experiment was carried out in the Louguantai State-owned Ecological Experimental Forestry Farm (33°42'-34°14'N 107°39'-108°37'E) in the northern foothills of the Qinling Mountains in Shaanxi Province, China. The samples were collected between June 2023 and June 2024.
Data exclusions	No data were excluded from the analyses.

Reproducibility	We have identified all data sources and made them publicly available, ensuring the reproducibility of the numerical analyses presented in this study based on the methods described in the Methods section.
Randomization	The experiment was established using a randomized complete block. Each plot was randomly arranged with more than 10 m buffers and encircled by 70 cm high PVC panels inserted 40 cm into the ground. Soil and plants samples were collected randomly from each plot.
Blinding	The field experiment was established using a randomized complete block design, and each sample was assigned a unique, randomly generated identification number.
Did the study involve field work?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

Field work, collection and transport

Field conditions	This region experiences a warm-temperate, semi-humid climate, with a mean annual temperature of 7.40 °C, mean annual precipitation of 600-1100 mm and mean altitude of 559-706 m asl. This forest was heavily logged in 1985 and has experienced various anthropogenic disturbances, including road and temple construction, understory plant harvesting, and intensive agricultural and industrial activities. After protective measures were implemented, the area developed into a young secondary natural forest dominated by <i>Quercus variabilis</i> , which represents approximately 70% of the species composition. The current total deposition rate in this study area is 34.8 kg N ha ⁻¹ yr ⁻¹ , of which dry deposition contributes 17.7% and wet deposition accounts for 82.3%. The ratio of NH ₄ ⁺ :NO ₃ ⁻ is 0.9.
Location	The experimental site is located in the Louguantai State-owned Ecological Experimental Forestry Farm (33°42'-34°14'N 107°39'-108°37'E) in the northern foothills of the Qinling Mountains in Shaanxi Province, China.
Access & import/export	As the experiment was conducted within China, no special permits were required for transferring soil and plant samples between research groups.
Disturbance	Minimal disturbance was caused in the field. No special permits were required to transfer soil and plant samples between research groups. Permission for field sampling was obtained from the Shaanxi Provincial Forestry Bureau.

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	Included 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
<input type="checkbox"/>	<input checked="" type="checkbox"/> Plants

Methods

n/a	Included 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

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 |
|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Public health |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> National security |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Crops and/or livestock |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> Ecosystems |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Any other significant area |

Hazards

Our research was focussed on comparing differences in nitrogen fate under canopy and understorey 15N tracer addition methods. The study does not involve any agents, technologies, or information that could pose a threat to public health, national security, ecosystems, or any other significant area, nor does it include any agents subject to oversight for dual use research of concern.

For examples of agents subject to oversight, see the United States Government [Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern](#).

Experiments of concern

Does the work involve any of these experiments of concern:

- | No | Yes |
|-------------------------------------|--|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Demonstrate how to render a vaccine ineffective |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Confer resistance to therapeutically useful antibiotics or antiviral agents |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Enhance the virulence of a pathogen or render a nonpathogen virulent |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Increase transmissibility of a pathogen |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Alter the host range of a pathogen |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Enable evasion of diagnostic/detection modalities |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Enable the weaponization of a biological agent or toxin |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Any other potentially harmful combination of experiments and agents |

Precautions and benefits

Biosecurity precautions

Our research was focussed on comparing differences in nitrogen fate under canopy and understorey 15N tracer addition methods. This work does not involve any biological agents, pathogens, or technologies that pose biosecurity risks.

Biosecurity oversight

This study poses no biosecurity risks and therefore required no external biosecurity oversight.

Benefits

Canopy and understorey nitrogen addition lead to different 15N recovery pathways, thus affecting the magnitude and timing of ecosystem N responses that we are able to detect. Moreover, our results reveal how atmospheric N forms (NH₄⁺ and NO₃⁻) differentially contribute to ecosystem N cycling, providing insights to improve representation of N processes in vegetation models and their link to carbon cycling.

Communication benefits

Communicating this research carries no potential risks, and its findings may improve the representation of nitrogen-carbon interactions in global carbon cycle models.

Plants

Seed stocks

Plant collection was conducted between June 2023 and June 2024 at the Qinling Northern Foothills sample site (33°42'-34°14'N 107°39'-108°37'E).

Novel plant genotypes

This study did not use any novel plant genotypes; all plant materials were naturally occurring wild-type specimens collected from the field.

Authentication

This study used only naturally occurring wild-type plant materials collected from the field. No authentication procedures for novel genotypes or mutation effect assessments were required, as no transgenic, gene-edited, or mutagenized plant materials were employed.