

## 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 type="checkbox"/>            | <input checked="" 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<br><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<br><i>Give <math>P</math> 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 checked="" type="checkbox"/> | <input 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

N/A

Data analysis

Sediment organic carbon reactivity indices were calculated using the commercial software Geoworks 1.9 (Vinci Technologies)  
All GIS analysis was performed in ArcGIS Pro 3.3.1 (ESRI)  
All data analysis and figure plotting was performed in RStudio 4.04.2 (RStudio Team)

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](#)

Hydrology, sediment carbon, gaseous carbon flux, and modelled dissolved carbon data that support the findings of this study are openly available at the Figshare repository: <https://doi.org/10.6084/m9.figshare.29500514>

## 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        | We investigated the annual and decadal carbon mass balance of a beaver wetland, by measuring all major aqueous and atmospheric exchanges, including biomass and sedimentary storages of carbon in field during 2022.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Research sample          | All data in this study were collected in field from the studied wetland, comprising 1) flow and stage measurements, 2) water sampling for determining dissolved carbon loads, 3) CO <sub>2</sub> and CH <sub>4</sub> fluxes from water, exposed sediments and deadwood, and 4) sediment carbon content quantified from sediment cores (see data availability statement).                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Sampling strategy        | Sediment sampling locations were distributed across the wetland to capture the spatial variation. The wetland was further divided into three subsections (upstream, midstream and downstream), based on their difference in hydrologic connectivity. Water extent were modelled for each subsection and GHG fluxes were also measured in each subsection.                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Data collection          | Data was collected from field measurements (flow measurements, stage sensor logging, GHG chamber measurements) and subsequent laboratory analysis (water chemistry analysis, sediment pyrolysis/oxidation analysis, water surface/volume estimation).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Timing and spatial scale | Fortnightly flow measurements and water sampling to determine water chemistry were performed over a year, at up- and downstream locations of the beaver wetland. Fortnightly sampling resolution of dissolved carbon concentrations were chosen because it is sufficient for accurate modelling of daily loads.<br>Carbon GHG fluxes were measured across upper, middle and lower sections of the wetland area, both from exposed sediments, water, and deadwood, at fortnightly temporal resolution. This was chosen to capture both within wetland variation as well as inter-seasonal dynamics.<br>Sediment samples were collected across the wetland during one occasion for analysis of C content. To determine vegetation and water extent, drone imagery were collected during five surveys across the year. |
| Data exclusions          | CO <sub>2</sub> and CH <sub>4</sub> concentrations with measurement errors (non-sealed chambers) were excluded from further analysis (n = 9).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Reproducibility          | This study reports observations based on monitoring of solute, particulate, and gaseous carbon species in a wetland. It did not involve any experiments.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Randomization            | Sediment sampling locations were randomly spread out across the wetland to capture spatial variation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Blinding                 | Not relevant for this study, in which no humans were involved.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

Did the study involve field work? ☒ Yes ☐ No

## Field work, collection and transport

|                        |                                                                                                                                                                                                          |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Field conditions       | Samples were collected in both wet and dry conditions throughout the study period (2022-01 to 2023-01). The temperature ranged between -10 to 36 °C (mean 11°C) and the annual precipitation was 711 mm. |
| Location               | The study site was a beaver wetland south of Marthalen (47.6° N, 8.6° E), in Canton Zürich, Switzerland.                                                                                                 |
| Access & import/export | The study site was accessed by obtaining permission from landowner. All collected samples were analysed in Switzerland.                                                                                  |
| Disturbance            | None. Wading in the wetland, sediment core sampling and installation of static GHG chambers had no discernable effect on the wetland biota or geomorphology.                                             |

## 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  |
| <input type="checkbox"/>            | <input checked="" type="checkbox"/> Plants             |

### 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 |

## 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 checked="" type="checkbox"/> | <input type="checkbox"/> Ecosystems                 |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> Any other significant area |

### 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         |

## Plants

Seed stocks

Vegetation was collected from field (five macrophyte species) in August 2022 by harvesting aboveground biomass from five plots (0.16 m<sup>2</sup>) throughout the wetland.

Novel plant genotypes

N/A

Authentication

N/A