

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 ( <i>n</i> ) 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 type="checkbox"/>            | <input checked="" 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. <i>F</i> , <i>t</i> , <i>r</i> ) with confidence intervals, effect sizes, degrees of freedom and <i>P</i> value noted<br><i>Give P 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 type="checkbox"/>            | <input checked="" 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 <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 | Total C concentration for each sample was determined by dry combustion using a Flash EA 111d CN Automatic Elemental Analyzer (Thermo Finnigan, Milan, Italy) |
| Data analysis   | Data was analyzed using R (v4.3.1) and SAS (v9.4).                                                                                                           |

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 soil data analyzed in this manuscript are available through Dryad doi:10.5061/dryad.b8gtht7mv

## Human research participants

Policy information about [studies involving human research participants and Sex and Gender in Research](#).

Reporting on sex and gender

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        | We measured soil organic carbon stocks in an agricultural field with seven different cropping system treatments. The experiment was a randomized complete block design with four blocks for the core six treatments and one block for the prairie treatment. Within each block, the treatments were assigned to a number of plots equal to the number of phases in their crop rotation (e.g. one plot for continuous maize, two plots for maize-soy, etc) such that different treatments had a different number of plots per block. |
| Research sample          | We sampled soils to a depth of 90 cm in an agricultural field. This data was combined with an existing dataset provided by Randy Jackson and Gregg Sanford involving the same location, which had been previously sampled in 1989 and 2009.                                                                                                                                                                                                                                                                                         |
| Sampling strategy        | We sampled at the center of each third of each plot. This allowed us to have a similar number of samples per plot as the original 1989 sampling scheme, which sampled on a 27 x 27 m grid across the entire field.                                                                                                                                                                                                                                                                                                                  |
| Data collection          | Soil samples were collected by field technicians using a hydraulic core. Samples for %C were sieved to 2 mm, dried, ground, and analyzed using a CN analyzer run by our lab manager. The analyzer automatically records %C as it combusts each sample. Samples for bulk density were placed in paper bags and dried until weights stabilized, then weighed. Clarissa Dietz recorded the weights in a Microsoft Word Excel sheet and divided them by the core volume to get the bulk density.                                        |
| Timing and spatial scale | Data were collected in 1989, around 2009, and in 2019. This timing was chosen to reflect the slow-changing nature of soil organic carbon. Plots are 18 x 156 m so that all fieldwork can be carried out with production scale farm equipment. Approximately three samples per plot are taken for each time point.                                                                                                                                                                                                                   |
| Data exclusions          | Data beyond two standard deviations were excluded for each combination of year, cropping system (treatment), and depth increment. These criteria were pre-established.                                                                                                                                                                                                                                                                                                                                                              |
| Reproducibility          | We did not attempt to repeat our 30 year study.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Randomization            | Location of treatments within blocks was assigned randomly. Blocks were treated as a covariate.                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Blinding                 | Blinding was not possible during data collection, since the technicians could see what field they were in. Once samples were collected and processed, they were assigned a number and referred to by that number until data analysis.                                                                                                                                                                                                                                                                                               |

Did the study involve field work? ☒ Yes ☐ No

## Field work, collection and transport

|                  |                                                                                                                                                                                                                                                                          |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Field conditions | We conducted this work on soils classified as Plano Silt loam (fine-silty, mixed, superactive, Mesic Typic argiudolls). These are relatively deep (~1 m), well drained soils with little relief that developed under tallgrass prairie vegetation in loess deposits over |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

calcareous glacial till. Mean annual temperatures and precipitation between 1991 and 2020 were 7.8 °C and 902 mm, respectively.

Location

The University of Wisconsin-Madison's Arlington Agricultural Research Station, in Arlington, WI (43°18'N, 89°20'W)

Access & import/export

The field site is owned by the University of Wisconsin - Madison and as such, we were able to access it legally and responsibly.

Disturbance

The sampling frequency of the study (once every ten years) was chosen to minimize disturbance to the soil resources. All other disturbances are equivalent to what the site would experience in the absence of our experiment: tillage, chemical application, and the other disturbances caused by using the land for agriculture.

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

- |                                     |                                                 |
|-------------------------------------|-------------------------------------------------|
| 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 |

## Animals and other research organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research, and [Sex and Gender in Research](#)

Laboratory animals

Study did not involve laboratory animals. There were heifers that grazed the pasture system.

Wild animals

Study did not involve wild animals.

Reporting on sex

The heifers that grazed the pasture were all female, since the pasture treatment is designed to mimic a custom heifer grazing operation which would provide female cattle to dairy herds. Male cattle do not produce milk. We did not collect data directly from the cattle; they were present solely to graze the pasture.

Field-collected samples

We did not collect samples from the heifers.

Ethics oversight

Our care of the heifers was overseen by the UW - Madison Research Animal Resource Center, which provided guidance on the study protocol.

Note that full information on the approval of the study protocol must also be provided in the manuscript.