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Supplemental information

Global changes and their environmental stressors have a significant impact on soil biodiversity—A meta-analysis

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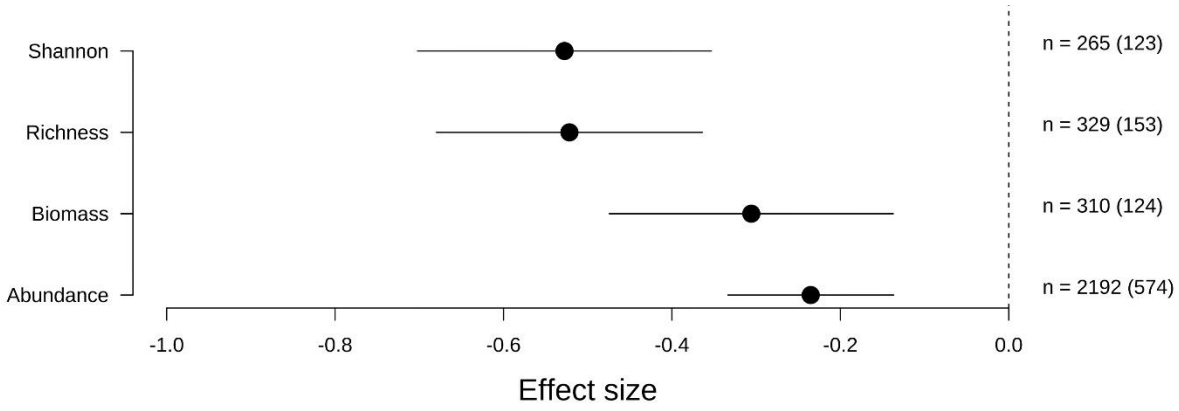


Figure S1: Impact of the community metric on effect size. Hedges' g was used as the effect size. Negative effect sizes indicate that the biodiversity measured using each metric has a negative impact from global change. A positive effect size indicates an increase in biodiversity for each measurement. Error bars indicate 95% confidence intervals. Effect sizes where error bars do not cross the dashed vertical zero line, are significantly from zero. The values of n indicate the number of cases of within each measurement type in the model, with values in parentheses indicating the number of publications.

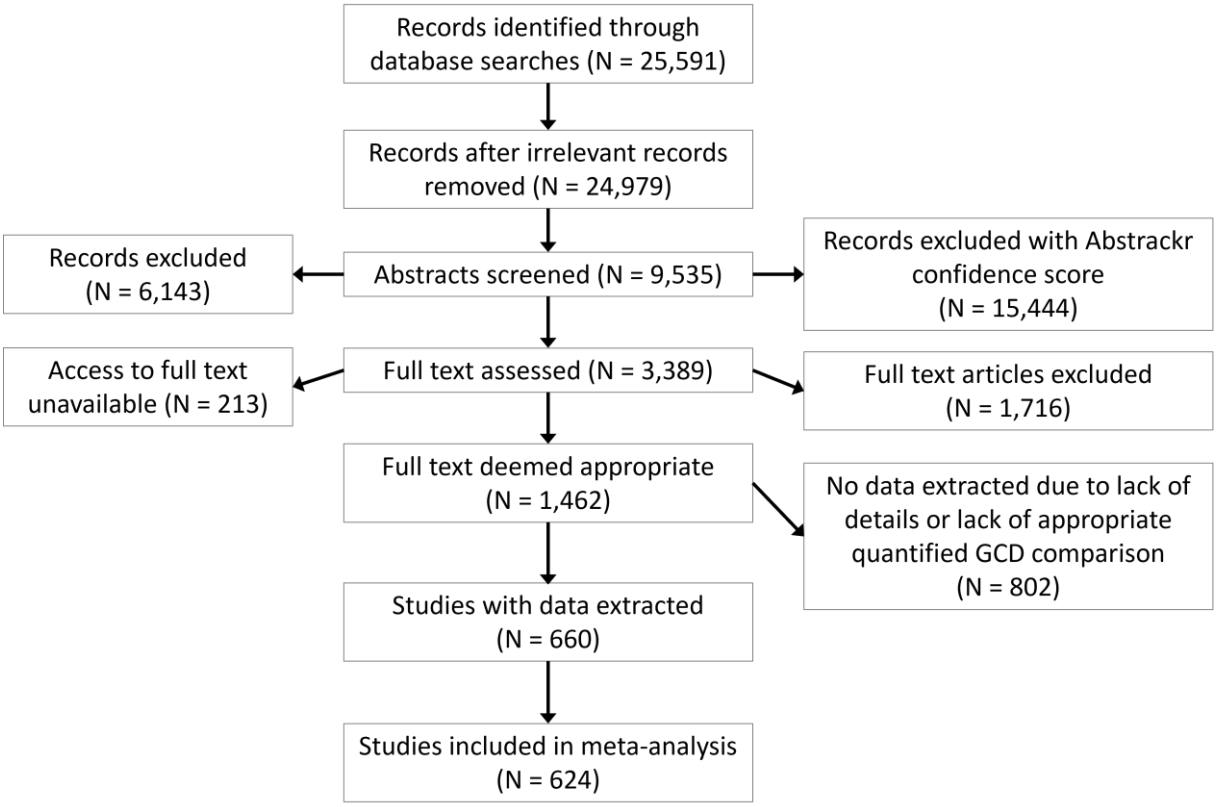
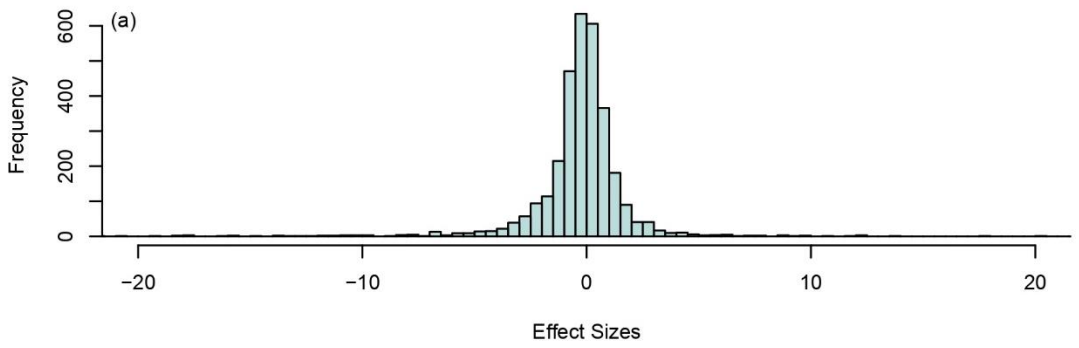


Figure S2: PRISMA diagram representing the workflow of the literature search.


(a)
Frequency
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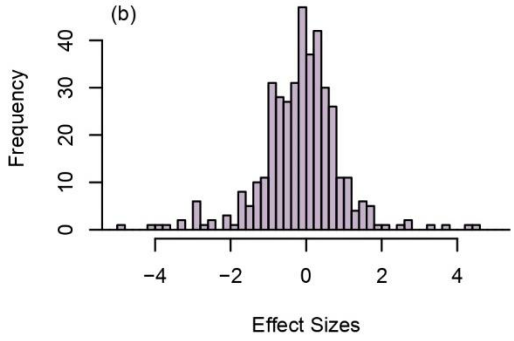
400
600
−20
−10
0
10
20
Effect Sizes


(b)
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20
30
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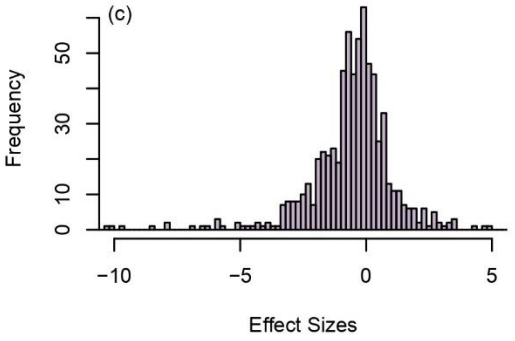
2
4
Effect Sizes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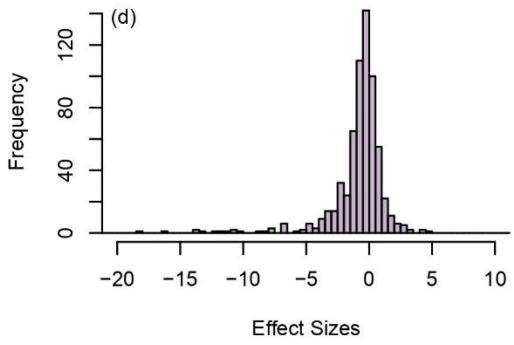
0
5
Effect Sizes


(d)
Frequency
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80
120
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−15
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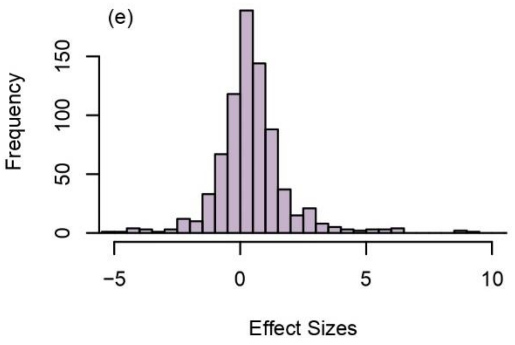
−5
0
5
10
Effect Sizes


(e)
Frequency
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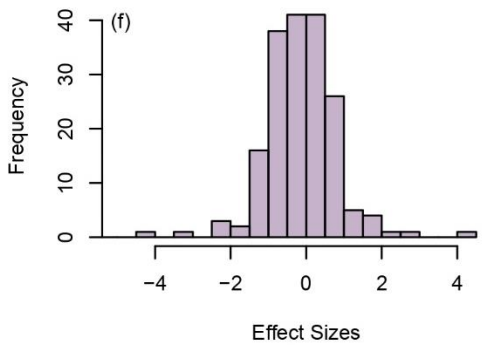
100
150
−5
0
5
10
Effect Sizes


(f)
Frequency
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10
20
30
40
−4
−2
0
2
4
Effect Sizes

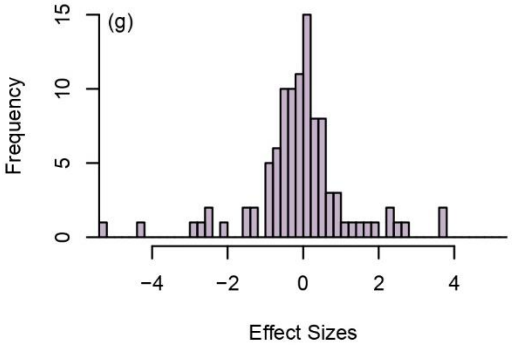

(g)
Frequency
0
5
10
15
−4
−2
0
2
4
Effect Sizes

Figure S3: Distribution of the effect sizes for (a) the full model of GCDs, and the environmental stressors associated with (b) climate change, (c) land use intensification, (d) pollution, (e) nutrient enrichment, (f) invasive species and (g) habitat fragmentation. To aid readability, extreme outliers have been excluded from the figures.

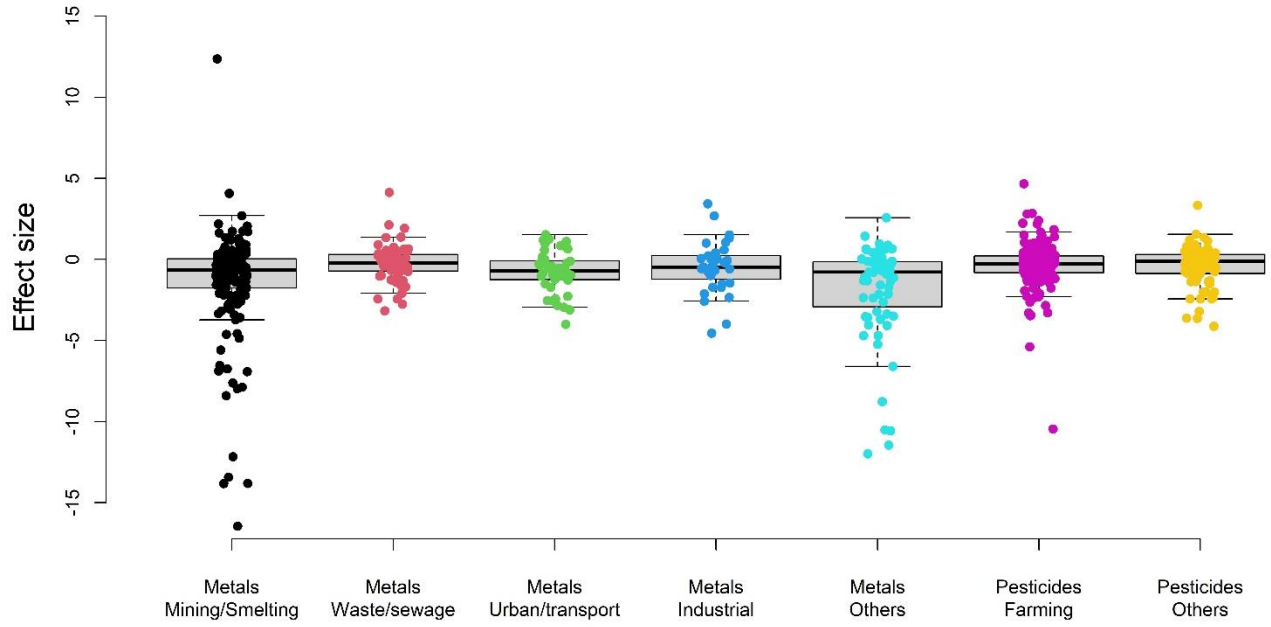
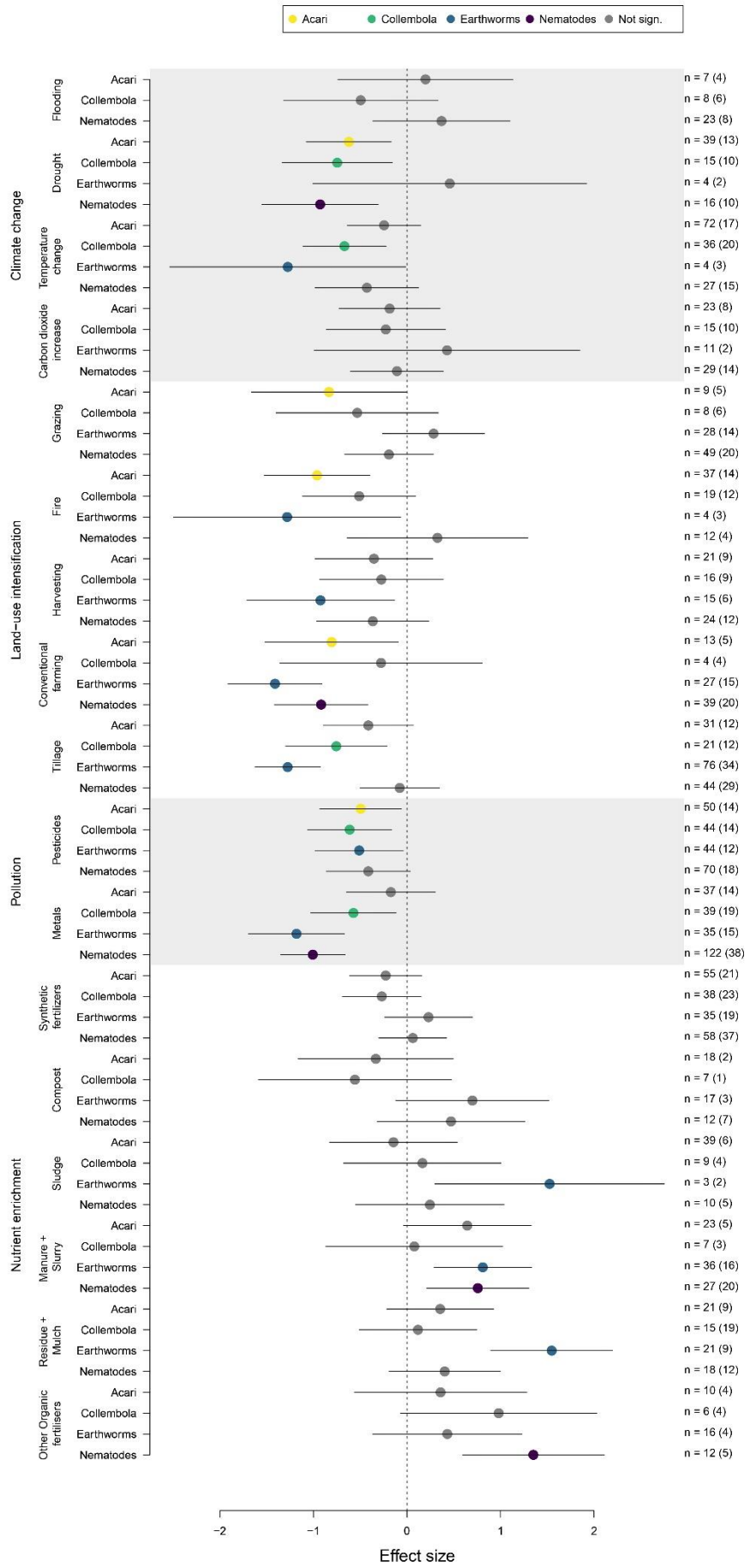


Figure S4: Raw effect sizes for the environmental stressors associated with pollution. Note, the y-axis has been truncated to -20 to 20, thus 8 effect sizes are not shown (three effect sizes < -20 from Metals - Mining/Smelting, Metals – Others and Pesticides – Others: five effect sizes > 20 from Metals - Mining/Smelting).


Acari
Collembola
Earthworms
Nematodes
Not sign.
Climate change
Land−use intensification
Pollution
Nutrient enrichment
Flooding
Drought
Temperature change
Carbon dioxide increase
Grazing
Fire
Harvesting
Conventional farming
Tillage
Pesticides
Metals
Synthetic fertilizers
Compost
Sludge
Manure + Slurry
Residue + Mulch
Other Organic fertilisers
n = 7 (4)
n = 8 (6)
n = 23 (8)
n = 39 (13)
n = 15 (10)
n = 4 (2)
n = 16 (10)
n = 72 (17)
n = 36 (20)
n = 4 (3)
n = 27 (15)
n = 23 (8)
n = 15 (10)
n = 11 (2)
n = 29 (14)
n = 9 (5)
n = 8 (6)
n = 28 (14)
n = 49 (20)
n = 37 (14)
n = 19 (12)
n = 4 (3)
n = 12 (4)
n = 21 (9)
n = 16 (9)
n = 15 (6)
n = 24 (12)
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n = 4 (4)
n = 27 (15)
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n = 44 (14)
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n = 70 (18)
n = 37 (14)
n = 39 (19)
n = 35 (15)
n = 122 (38)
n = 55 (21)
n = 38 (23)
n = 35 (19)
n = 58 (37)
n = 18 (2)
n = 7 (1)
n = 17 (3)
n = 12 (7)
n = 39 (6)
n = 9 (4)
n = 3 (2)
n = 10 (5)
n = 23 (5)
n = 7 (3)
n = 36 (16)
n = 27 (20)
n = 21 (9)
n = 15 (19)
n = 21 (9)
n = 18 (12)
n = 10 (4)
n = 6 (4)
n = 16 (4)
n = 12 (5)
−2
−1
0
1
2
Effect size

Figure S5: Change in the biodiversity of four soil taxa groups (Acari, Collembola, earthworms, and nematodes) in response to the stressors of four global changes (GCs). Hedges' g was used as the effect size. Negative effect sizes indicate that the stressor causes a reduction in biodiversity, and a positive effect size indicates an increase in biodiversity. Error bars indicate 95% confidence intervals. Effect sizes where error bars do not cross the dashed vertical zero line, are significantly different from zero. Effect sizes which are not significantly different from zero are dark grey, other colours indicate the different taxa groups. The values of n indicate the number of cases of each taxa group within each stressor category in the model, with values in parentheses indicating the number of publications. Grey shading in background is for enhancing readability only. Note, there was no data representing earthworms impacted by Flooding, so no effect size is shown.

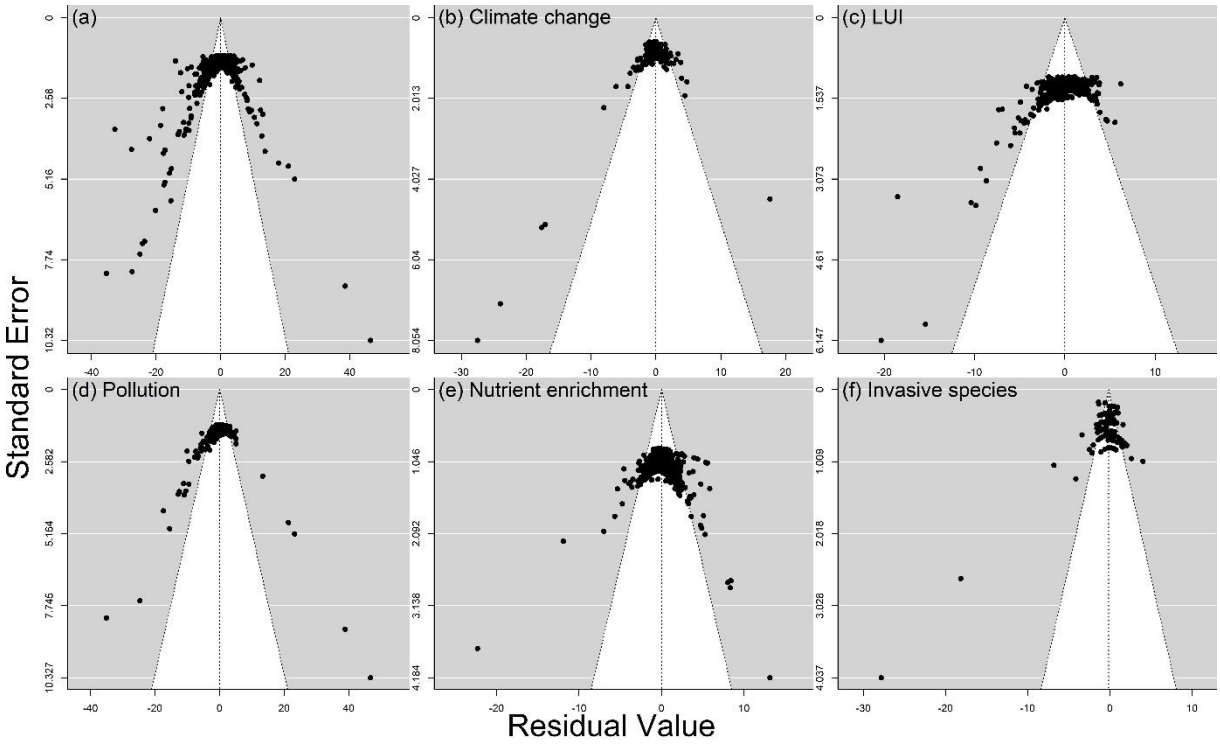

Figure S5: Funnel plots of data used in (a) the full model of GCDs, and the environmental stressors associated with (b) climate change, (c) land use intensification, (d) pollution, (e) nutrient enrichment and (f) invasive species. A funnel plot that is symmetrical would indicate no publication bias.

Table S1: Full list of GCDs and their associated stressors. Not all stressors had enough data to be included in the environmental stressor models, stressors in italics were excluded from the environmental stressor models, but not the main GCD model. Examples column provides some details of the type of data included in each stressor, but is not an exhaustive list.

Global Change	**Environmental stressor**	**Examples**
Climate change	CO_2 increase	Increase in amount
	Temperature change	Increase in amount, duration. Changes in number of freeze/thaw cycles
	Water availability – Drought	Decrease in water amount, rate, duration
	Water availability – Flood	Increase in water amount, rate, duration
	O_3 increase	Increase in amount
	Precipitation and Temperature change	Both changes in precipitation and temperature
	UVB Radiation	Increase in amount
Land use intensification	Grazing	Vertebrate and invertebrates, foliage removal (as proxy)
	Organic versus conventional farming	Combination of intensive agricultural practices (e.g. tillage, synthetic fertilizers) compared to more extensive practices used in organic farming (e.g. no tillage, organic fertilizers)
	Harvesting	Logging, selective harvesting, thinning, clear cut
	Fire	Controlled burns, wildfires, changes in intensity, amount, duration
	Tillage	Reduced, shallow depth, conventional
	Degradation	General disturbance and degradation (non-descript)
	Human population	Rural to urban comparisons
	Management	Weeding, planting rate, planting mechanism, landscape practices
	Irrigation	Specific water management (unrelated to climate change)
	Mono- versus poly-culture	Mixed agriculture (plantations, crops) compared to monoculture
Pollution	Metals	Lead (Pb), Cadmium (Cd), Zinc (Zn)
	Pesticides	Insecticides (e.g. neonicotinoids), Herbicides (e.g. glyphosate), Fungicides (e.g. carbendazim), fumigants
	Antibiotics	Bactericides, formaldehyde
	Endocrine disruptors	Bisphenol A, phtalates
	Radionuclides	Uranium, radiation
	Nanoparticles	Carbon nanomaterials
	PAHs	Accidental fuel or oil spills
	Pharmaceuticals	Ivermectin
	Salinization	Salt (chloride, sodium)

	Sulphate	Acid sulphate pollution
Nutrient enrichment	Synthetic fertilizers	N, P, K, NPK, compound fertilizers
	Ca-liming + Wood ash	Calcium carbonate, Ca(OH)2
	Compost	Vermicompost, farm compost, garden waste
	Manure + Slurry	Farmyard manure, animal manure, green manure, cattle slurry
	Mixture	Two or more different types of fertilizer
	Other Organic fertilisers	Sugars, bone meal, soybean byproducts
	Residue + Mulch	Straw, pine, clover residue, bark mulch, rice straw mulch
	Sludge (including Biosolids)	Sewage sludge, dried sludge
	Biochar	Wood biochar
Invasive species	Aboveground animal	Vertebrates, invertebrates
	Belowground animal	Invertebrates
	Plants - non-woody	*Microstegium* spp, *Spartina* spp, *Heracleum* spp
	Plants – woody	*Ailanthus* spp, *Robinia* spp
	Plants – mixture	Two or more invasive plants at a site
Habitat fragmentation	*Edge effects*	Distance from edge
	Fragmentation per se	Number of patches (constant area)
	Habitat amount	Decrease in area
	Isolation	Distance to source
	Corridors/Connectivity	Fragments connected or not

Table S3: Estimates, confidence intervals, z-values and p-values from the model showing the impacts of GCs on four taxonomic groups; acari, collembola, earthworms and nematodes. ':' indicates the interaction between the taxonomic group and the GC.

Term	Coefficient	CIs	z-value	p-value
Climate	-0.32	[-0.69,0.04]	-1.75	0.08
LUI	-0.61	[-0.94,-0.27]	-3.55	0.0004
Pollution	-0.54	[-0.91,-0.17]	-2.89	0.004
Nutrient enrichment	-0.09	[-0.44,0.25]	-0.53	0.59
Invasive species	-0.32	[-1.10,0.45]	-0.82	0.41
Habitat fragmentation	-0.51	[-1.22,0.19]	-1.42	0.15
Collembola	-0.30	[-0.63,0.04]	-1.75	0.08
Earthworms	0.26	[-0.59,1.11]	0.61	0.54
Nematodes	0.02	[-0.40,0.44]	0.10	0.92
LUI:Collembola	0.37	[-0.11,0.85]	1.50	0.13
LUI:Earthworms	-0.76	[-1.68,0.16]	-1.62	0.11
LUI:Nematodes	0.26	[-0.29,0.80]	0.92	0.36
Pollution:Collembola	0.15	[-0.34,0.63]	0.60	0.55
Pollution:Earthworms	-0.49	[-1.43,0.44]	-1.03	0.30
Pollution:Nematodes	-0.31	[-0.88,0.26]	-1.07	0.29
Nutrient enrichment:Collembola	0.27	[-0.19,0.73]	1.15	0.25
Nutrient enrichment:Earthworms	0.60	[-0.34,1.54]	1.25	0.21
Nutrient enrichment:Nematodes	0.34	[-0.20,0.88]	1.22	0.22
Invasive species:Collembola	0.14	[-0.74,1.01]	0.31	0.76
Invasive species:Earthworms	0.64	[-0.67,1.96]	0.96	0.34
Invasive species:Nematodes	-0.26	[-1.30,0.78]	-0.49	0.62
Habitat fragmentation:Collembola	0.79	[-0.02,1.60]	1.91	0.06
Habitat fragmentation:Earthworms	-0.07	[-1.42,1.27]	-0.11	0.91
Habitat fragmentation:Nematodes	0.09	[-0.84,1.02]	0.19	0.85

Data S1: Search terms

TS=(“global change” OR “environmental change” OR disturbance* OR stress*)

TS=(“land-use” OR “landuse” OR “land use” OR “agricultural intensi*” OR forest* OR agricultur* OR grassland* OR pasture* OR meadow* OR agroforest* OR plantation* OR urban* OR farm* OR abandon* OR fallow* OR graz* OR arable OR till* OR ploug* OR habitat degrad*” OR “habitat destruct*” OR logg* OR deforest* OR ((“land use” OR “landuse” OR “land-use OR cropland OR agricultur*) AND (intensi* OR expansion)))

TS=(“habitat loss” OR “habitat fragment*” OR “edge effect*” OR fragment*)

TS = (“climat* change” OR drought OR temperature* OR warming OR heat* OR precipitation* OR rain* OR flood* OR irrigation OR moisture OR watering OR fire OR “carbon dioxide” OR CO2)

TS=(pollut* OR contamin* OR toxi* OR metal* OR asbestos OR radionuclide* OR radioactiv* OR pharmaceutic* OR “emerging contamin*” OR “synthetic organic chem*” OR “personal care product*” OR plastic* OR “polycyclic aromatic hydrocarbon*” OR pesticide* or herbicide* or fungicide* or molluscide* or nematicide* or insecticide* OR agrochemical* OR “oil spill” OR “brine spill” OR “petrol spill” OR mining OR smelting OR “industrial activit*” OR “waste disposal” OR wastewater OR sludge OR sewage)

TS=(“nitrogen deposition” OR “nutrient deposition” OR “atmospheric deposition” OR *eutroph* OR fertili* OR “nutrient* enrichment” OR “nutrient pollut*”)

TS=(invad* OR exotic OR alien OR invas* OR non$native OR peregrine OR introduc* OR non$indigenous)

TS=(“species richness” OR richness OR “number of species” OR “number of taxa” OR diversity OR biomass OR Shannon* OR evenness OR abundance OR density OR communit*)

AND

TS=(
(((soil OR below$ground OR below-ground) AND (biota OR fauna OR micro$fauna OR macro$fauna OR meso$fauna OR animal* OR arthropod* OR invert* OR “inverte* decomposer*” OR detritivore* OR macroarthropod* OR rotifer* OR mite* OR acari* OR protozoa* OR tardigrad* OR isopod* OR protist* OR micro-arthropod* OR microarthropod* OR ciliat* OR termit*)) OR nematod* OR oligochaet* OR annelid* OR collembol* OR springtail* OR earthworm* OR enchytrae* OR lumbricid* OR “soil biodiversity” OR “below$ground biodiversity” OR “soil divers*” OR “below$ground divers*”))

The search retrieved 25,591 records, that were further filtered to remove obviously irrelevant papers using the Web of Science categories (MARINE FRESHWATER BIOLOGY OR OCEANOGRAPHY OR LIMNOLOGY were excluded) and non-primary research articles (REVIEW OR MEETING ABSTRACT OR NOTE OR NEWS ITEM OR RETRACTED PUBLICATION OR BIBLIOGRAPHY OR DATABASE REVIEW).

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Data S2: Data Extraction Protocol:

Overview of steps in the meta-analysis

- Review the titles and abstracts of all papers gathered from the literature review
    - This will be done alongside Abstraktr
- For the papers that seem suitable from the titles and abstracts, the full text will be reviewed
- Papers that are suitable based on the full text will have data extracted

Title and abstract screening - General Overview

In order to be suitable for the meta-analysis the abstract should mention data that looks at the effect of a global change driver on soil invertebrates diversity.

A global change (GC) should belong to one (or more) of the following six categories:

- Land use intensification
- Habitat loss or fragmentation
- Pollution
- Nutrient enrichment
- Climate change
- Invasive species

A soil invertebrate includes many things, but not microbes.
Microbes are:

- Bacteria
- Archaea
- Fungi

We are also not including protozoa

Soil invertebrates (in this stage – the full text screening stage has a different protocol) *can* include (but is not limited to):

- Ants
- Termites
- Beetles
- Spiders
- Earthworms
- Larvae (of many invertebrates)
- Collembola
- Nematodes

- Mites
- Isopoda
- Diplopoda
- Chilopoda
- Molluscs (Gastropods)

The diversity data needs to include the diversity of all animals within the group(s), i.e., not just one or a couple of species.
The data will need to include diversity data, such as:

- Species richness
- Abundance
- Biomass
- Shannon diversity

Global Changes

We are expecting papers that contain a control (i.e., less intensive) sites compared to one (or more) more intensive sites. At each site they would have measured the diversity of the soil invertebrates.

Land Use Intensification

As we don't want too much overlap between the global change categories, it is likely that 'land use intensification' will only be applied to sites that have an increase in *mechanical* inputs. For example, a change in tillage, removal of yield (i.e., grass, wood), grazing. Changes in fertilizing rates, pesticide use will be in other GCD categories. A change from an organic system to an inorganic system will also be considered a land use intensification if the exact changes is not given (or can't be split apart).
A study may have data from different systems (i.e., a forest, a grazed grassland, an urban site), but cases must be within at least one/each system there is a change in intensification. We will only use the systems that have a change in intensification.

A note on Land Use Change

We will not be using any land use change studies in this meta-analysis. But will still be identifying them at this stage, so we could at a later date.
A land use change study is where multiple sites only exist in multiple types of systems. For example, a grazed grassland versus a forest versus an urban site. There is no change in intensification measured within any of the systems.

Habitat loss or fragmentation

The studies will have sites in habitats (of any system) that change in their size, isolation or disturbance.
They will (most likely) fall into three main categories:

- Changes in habitat amount across sites
- Changes in distance to the edge of the habitat across sites
- Changes in the connectivity of the habitat to other habitats

Pollution

Pollution studies will have multiple sites that vary in the amount (or type) of pollution.
Broadly, pollutions may be:

- Pesticides (targeted or non-targeted)
- PAHs
- Plastics
- Antibiotics
- Metals (Cd, Pb, Zn etc.)
- Asbestos
- radiation

Nutrient enrichment

As with pollution, nutrient enrichment studies will have sites that vary within or between two main types of nutrient enrichment - organic and inorganic.
Organic:

- Manure
- Mulch
- Sludge
- Slurry

Synthetic (i.e. chemicals including specific elements):

- N, P, K (and any mixture of them)
- Ca
- S

Climate change

Climate change studies will cover a whole range of treatments. Sites will often have a change in the intensity, frequency or amount of the treatment:
Treatments includes:

- Gas (N_2O, CO_2, CH_4)
- Fire (only in relation to climate change, not natural burning)
- Precipitation

- Temperature
- Mixture of climate treatment
- Extreme events

Irrigation is not a climate change, as this is assumes that crops get the water that is the normal amount. The treatment needs to be a manipulation away from the normal amount/frequency.

Invasive species

We foresee three main types of invasive species studies:

- Those where plants are the invasive species
- Those where animals are invasive (the animals may be aboveground or belowground
- Where pathogens are invasive

Studies will either be testing where sites have no invasive species versus where they do, and sites that have less invasive species than other sites.

Full Text Screening – General Overview

In order to be suitable the main text needs to present data (either in the text, table or figure), show appropriate methodology, and an appropriate global change driver.

1. Methods

The appropriate methods are as following:

- Soil core (any size)
- Soil\Leaf litter quadrats
- Soil pit
- Chemical expulsion (hot mustard, mustard, formalin, AITC)
- Berlese–Tullgren funnel sampling (technically done using a soil core, but may only mention this part)
- Pitfall traps only in combination with one of the above methods

The data will not be considered ‘soil biodiversity’ if *only* pitfall traps are used.

Mesocosms:
If the mesocosms have been taken from the field, and the community not manipulated or the soil sterilised, then it is fine to be included. If the experimental design had a fully manipulated communities (i.e., “we added four species”), and therefore the soil was probably sterilized, then we do not want these studies included.

2. Available data

Look through the paper for figures, tables, supplementary material, and data in the text.

We need means/averages from the different treatments, and standard deviation (SD) or standard error (SE(M)) or confidence intervals (CIs), and the sample size in the different treatments. For metrics related to species composition (Shannon, Simpsons, Evenness) we do not require the variances, so do not exclude papers that only include these.

We do not want PCA/MCA/CCA/multivariate analyses.

3. Global changes

It is fine for a study to have more than one global change driver.

Temporal versus spatial contrasts
We will accept studies that look at sites that vary in space as well as samples that vary in time (i.e., a site that is sampled when not polluted and again later when it has been polluted.)

Restoration (after pollution)
In an study that's investigating the impact of active restoration (or a study comparing different types of restorations), such as planting trees, this should not be included, as it's a land use change study. This include those with are occurring after mining activities (i.e. pollution studies). In area where there was mining (as an example of a pollution) and there is active restoration (i.e., planting trees), this study will be considered as a pollution study and a land use change study.

Compaction studies
Only included if in relation to another global change as the underlying cause, e.g., compaction due to grazing animals versus non, or other agricultural practices (in this case, it would be an intensification).
If they only look at the effect of compaction on diversity, then this is not suitable.

Climate studies
Most likely this will be experiments where e.g., rainfall or temperature is manipulated. Spatial sites with different in temperature or precipitation will probably be excluded, unless, the authors specifically state they are trying to reproduce climate change with a gradient.
However, some studies may be temporal sampling (over many years) to try and understand changes in climate, these are suitable.

Fire
Most of the time, fire studies are prescribed burning. In which case they are an intensification study. However, if the paper is framed in the context of climate change, then it would be included in climate change.

Altitudinal studies
Similar to climate studies, if the author is using elevation to reproduce a climate change scenario, we will include them. If it is just to look at the effect of elevation, exclude.

Wetlands: include them (including paddy fields too)
As long as they have sampled the soil under the water, these can be included.

GMOs
Exclude if only investigating the effect of the GMO crop. But can be included if, for example, they include land use intensification impacts in a GMO-crop field and non-GMO-crop field.

Sludge application
Unless they quantify the chemicals within the sludge, it is only nutrient enrichment. Otherwise it can also be a pollution study.

Vermicomposting
If vermicompost had been applied to the soil, it is nutrient enrichment. If they are just looking at the process of vermicomposting, then exclude.

Acidification
Changes in pH are not considered as a global change in this meta-analysis. Acidification can be nutrient enrichment or pollution depending on the study design and focus:

- studies that report addition of N or S (e.g. H2SO4) will be nutrient enrichment (S is a nutrient)
- Studies that focus on the increased solubility in toxic heavy metals (Al and Fe) resulting from acidification will be tagged pollution

Data Extraction Protocol – General Overview

1) Check the paper and look at the figures and tables: if the paper does not report standard deviations or errors for abundance and richness data, the paper can be readily excluded (but not for Shannon or other diversity metrics).

2) If the paper is relevant, start data collection: Create an excel sheet in the Screening/Studies folder, named with the ID of the paper (also, name the folder the same).

3) Identify the different cases by reading methods and figures (different drivers, metrics of diversity and so on), and report them in the excel sheet.

4) Collect the data: using WebplotDigitizer for the figures (WebPlotDigitizer), for the tables you can try using pdftoexcel (that does not always work though: https://www.pdftoexcel.com/), All the data collected that way need to be pasted to the excel sheet associated with the paper in the Studies folder, in a folder named with the ID (this folder should also contain the PDF of the study and anything else needed during data extraction). If the study has multiple drivers, collect all the cases.

5) Fill the data extraction table with the data collected.

Data Extraction Protocol – General Information

Means and SDs

If a study does not have SDs (or SEs or CIs) for species richness, abundance or biomass values, then we are excluding the data.

For Shannons and evenness values do not exclude data if SDs etc. are missing.

If a case gives an error bar, but does not say what it is, then mark it as 'Unknown'.

Definition of Case

Within each paper, there can be any number of cases. These can corresponded to :

- Different taxonomic groups
- Different biodiversity measurements (e.g. shannon vs. taxa richness)
- Different types of global change (e.g. CO_2 and temperature treatments, each with a control)
- Different land use covers/habitat cover/plant species richness/cover crops
- Separated lab and field experiments
- Data from geographically separated areas (different countries, different landscapes if the primary studies also have them separated)

How to deal with multiple treatment levels

When paper reports several global change intensities (like a gradient) we only keep the highest intensities (i.e., the control and the most extreme treatment).

If a paper has a replicated design (i.e., a control for every treatment plot), then multiple comparisons can be made (this design is unlikely to appear in the literature often). The comparisons made depend on the number of different "treatments"

How to deal with multiple cases within and across global change types

Take the following experiment design, where an author manipulated temperature and CO_2. There would be two cases in this; *a* - where CO_2 was manipulated and the other "treatment" is at its control, and *b* - where temperature is increased and the other "treatment" is at the control.

	Ambient temperature	Increased temperature

Ambient CO2	a, b	b
Increased CO2	a	

So the rule is: when there are more than one treatment, each treatment should be a case, where all other treatments are at their lowest intensity. This also applies when the treatments are in different global change categories. It also applies if there are more than two GCs.

How to deal with multiple sampling times

When paper only reports several sampling dates: Only keep the last point in time for both the control and treatment. This includes recovery studies where the treatment stopped but authors followed soil fauna recovery over time.

Relative abundance data

We only extract the total abundance, not the relative abundance.

Taxonomic level

We extract biodiversity data at the highest level of taxonomic resolution possible but above family level data (i.e., we don't want abundances of a single species), enchytraeids are the exception to this rule.

If the paper reports the response of ALL the taxonomic groups they considered (for example they considered macrofauna, and reported the means and variance at this level) but they also report the response of *some but not all* of the taxonomic groups belonging to the macrofauna category they found (earthworms, millipedes, etc.), then we would extract only the lower resolution (for example paper looking at macrofauna response, reporting the overall abundance of macrofauna, and the abundance of earthworms only, we extract only the macrofauna data).

If the data is split into, e.g., "nematodes, collembola and other mesofauna"?: If there is a total mean abundance, then just use the mean total abundance. If there is no mean total abundance, then discard the "others" group, and just use, in this case, nematodes and collembola.

We don't extract at the lowest functional group reported. For example, if the author reports for different feeding groups of nematodes, this should be pooled. Unless there is strong reason to believe that not all nematodes were reported.

Functional/feeding groups

Pool across different functional/feeding/r-k-strategies/taxonomic groups, if all of them are reported. If only some are reported, they will need to be excluded (for example, a study might study all earthworm ecological groups, but only present the epigeics).

To pool:
Take the average of the mean values of different functional groups for control and treatment levels.
If errors are reported in SE you have to transform to SD first.
SD = SE * SQRT(n)
Where *n* is the number of samples that calculated that SE.

Then use the formula below to calculate the pooled standard deviation for each of the control and the treatment levels

$$s_{\text{pooled}} = \sqrt{\frac{s_1^{\,2} + s_2^{\,2} + \ldots + s_k^{\,2}}{k}}$$

Where s1, s2, … are the standard deviation associated to each functional group,
And k is the number of functional groups

In excel: SQRT(SUM(s1^2, s2^2, S3^2….)/[the number of S's])

Depth profile

When authors report diversities for different depth profiles (i.e., 0-10cm, 10-20cm), then only use the data for the top/shallowest depth. But always use the aggregated data if it is given.

Soils with different land covers/uses?

We only focus on comparisons within similar land cover/uses (forests/grasslands/croplands). But there can of course be cases across different land covers etc.

Decimal values

Please use American/English conventions for inputting decimal points (i.e., a fullstop [.] not a comma).

Coordinates

Use d/m/s format in the sheet.

Pitfall trap results

We don't collect those data, except if the authors report combined pitfall+soil samplings

Duplicated data and studies

When the paper reports different times only use the last point in time.

However, when reported in separate studies (e.g. one study published in 2013 reports data for 2013, and another paper about the same experiment/site reports data in 2015), extract both papers.

Boxplots

Only consider boxplots if it states it's the mean.

Unclear control sites

If different treatments are compared and it’s not clear which is the least intense (i.e. the control) or the authors don’t state, the paper is excluded (for example if there are several crop rotation treatments and none of them can be clearly identified as the least intense compared to monoculture treatment, this would be excluded). A control is needed.

Confidence interval

Use the value of the upper limit of the confidence interval in the “_SD” columns.

Plant diversity experiments

If a paper has data across a manipulated plant diversity gradient, then only use all the data, but have the different diversity groups as different cases.

Data Extraction Protocol – datasheet information

Information on the data collected in the data sheets.

Column_Name	**Description**
ID	Unique ID (number) given to each paper produced from the literature search
Author	The surname of the first author on the paper
Title	The title of the paper
year	The year the paper was published
DOI	The DOI of the paper
Case_ID	A unique identifier (character) for each case within the paper. A case is a comparison between a control and treatment. Different taxa groups, different measurements, different habitat types will each be different cases
driver	Which broad Global Change category is being measured
UniqueID	A unique identifier based on the paper ID, driver, and case ID

GCDType	Within the broad global change category, which stressor is being studied
System	What system is the study performed in
Harmonised	The taxa group being studied. The names have been harmonised across all papers (correct spelling errors, capitalisations etc)
GSBA	The taxa group being studied based on the categories presented in the Global Soil Biodiversity Atlas
Body.Size	The size of the group being studied. Either given in the paper or determined based on the GSBA classification
Control_mean	The mean of the biodiversity in the control sites
Control_SD	The standard deviation of the mean in the control sites. This has been harmonised from all variances given in papers.
Control_N	The number of samples that were used to calculate the mean in the control sites
Treatment_mean	The mean of the biodiversity in the treatment sites
Treatment_SD	The standard deviation of the mean in the treatment sites. This has been harmonised from all variances given in papers.
Treatment_N	The number of samples that were used to calculate the mean in the treatment sites
Measurement	What type of biodiversity measurement is being measured in this case
Error	What type of error (for the means) is being measured
yi	The effect size of the case (Hedges)
vi	The variance of the effect size for the case
effect	The effect size for the case (Hedges) - this is the same as yi, just a different column name
var	The variance of the effect size of the case - this is the same as vi, just a different column name
sei	The standard error of the effect size of the case (i.e., the square root of the sampling variance of the effect size)
year.c	The year the paper was published but centred on the mean
Data_Source	Where the data for this case was located in the original publication