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Supplementary Materials for

Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances

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Other Supplementary Material for this manuscript includes the following:
(available at science.sciencemag.org/content/368/6489/417/suppl/DC1)

Data S1 and S2

Materials and Methods

Data collection and selection

We searched the scientific literature and public data repositories for time-series of freshwater and terrestrial insect and arachnid assemblages, spanning at least 10 years between the first and last sampling date. We only included time-series that were (i) collected using consistent, standardized methods over time, (ii) were collected at the same site each time, and (iii) were or could be aggregated at the family level or higher (in one case subfamily level) taxonomic resolution to attain a measure of total insect numbers. Total insect numbers were either reported as total biomass or total abundance of any assemblage. Worms, mollusks, crustaceans and myriapods were excluded from datasets whenever possible, to maintain consistency with recent case-studies (*10*, *11*). Thus, our dataset contains mostly insects and arachnids. We included two datasets with only nine years of data because of the paucity of data from these regions: butterflies in Israel and beetles in Ukraine.

The publications were found using Thomson-Reuters Web of Knowledge, using the following search-terms: "insect", "arthropod" and "invertebrate", “beetle*”, “butterfl*”, “moth*”, “*flies”, “bee*”, “grasshopper”, “herbivore”, “pollinator”, “mosquito*”, in combination with “biomass”, "abundance", "community dynamics", “temporal”, “trend”, “monitor*” “dynamics”, “long”. This yielded ~5100 titles, which we first scanned by topic, and the remaining papers by study duration, taxonomic scope, methodological consistency and assemblage metrics reported. For the search of literature in Russian, elibrary.ru and Google Scholar were used with the same combinations of keywords. Additionally, we searched for data meeting our criteria in the following data repositories: BioTIME(*37*), GPDD(*38*), the LTER repository (www.lternet.edu), Knowledge Network Biocomplexity (https://knb.ecoinformatics.org/), the LTREB database, the Global Biodiversity Information Facility (www.gbif.org) and VectorBase (*39*). This yielded 166 studies from which data could be extracted. We extracted time series of insect abundance and / or biomass over time from figures, tables, appendices and linked data repositories. Several authors also provided original data upon our request. A full list of included studies is available in Table S1. To obtain a metric as close as possible to total insect abundance, the abundances or biomass reported for all taxa or functional groups were aggregated at the highest possible taxonomic resolution per reported sampling event, typically family level or higher (order, class or phylum).

In all, our dataset contained 166 studies covering 1676 sites in 41 countries. The median time-span was 15 years, ranging between 9 and 80 years, and between 1 and 264 individual sites. In the individual studies, the results per sampling event were reported at temporal scales ranging between daily samples to 5-year periods. For analysis, we included data at a temporal resolution between weekly and yearly values. Hence, when the sampling events were reported within a week, these were summed or averaged, and when data were presented as an average over several years, the mean of these years was used for input. In cases of multiple replicates per site (e.g., multiple soil cores, traps or net sweeps), these were summed, or in case of randomly missing samples, averaged, to produce one value per site per sampling event.

We classified all datasets according to realm (terrestrial or freshwater, where all samples collected in the water, as well as datasets aimed at collecting taxa with aquatic larvae in flight, such as mosquitoes or dragonflies, were classified as freshwater). To check for overlap in species between the terrestrial and freshwater datasets, we assigned a larval substrate to each taxon in our database. From this, we estimate that in total less than 0.1% of all individuals in our data that spend a portion of their life cycle in freshwater were collected in the surveys aimed at terrestrial insects, suggesting that the communities collected from the two realms were largely independent. Only one terrestrial dataset contained at least 19% individuals that have developed in the freshwater, and two other datasets contained some 2.5% individuals from the freshwater, whereas most contained none. We also classified all datasets according to country and continent of provenance, as well as its ecoregion according to the WWF classification (*40*). We aggregated these ecoregions into four climatic zones: boreal & high alpine, temperate, drylands (Mediterranean climate, deserts and xeric scrublands), and tropical. For each dataset, we also classified the stratum in which the insects were sampled: air (transect counts, suction pipes, light traps, malaise traps, window traps and pan traps), tree layer (arboreal window traps, visual counts), herb layer (sweep-net transects, suction sampling, sampling rings, visual counts), soil surface (pitfall traps, and ant nest counts), below ground (soil cores), or below water (e.g. kicksamplers, Surber samplers, aquatic emergence traps, see Fig. S2 for results and more details). Sticky traps were classified based on their placement: in the herb layer, on the soil surface, or in midair.

To test for general associations between insect abundance trends and global change drivers, we extracted environmental data for each of our 1676 sites on five global change drivers: protection status, percentage cover of urban and cropland at local and landscape scales, and changes in temperature and precipitation at local and landscape scales over the sampling period.

Protection status was determined by whether a site was included in the World Database on Protected Areas(*41*), providing a binary explanatory variable. At 207 sites, the protection status improved during or after the sampling period, but because protected status is typically only awarded to high quality ecosystems, we assumed that before the year of protection, these sites were already of high quality. For analysis, we thus designated ‘protected’ status to all sites that received protected status at any time before, during or after sampling.

To obtain approximations for land-use at and surrounding the sampling sites, we extracted the urban and cropland cover percentage at these sites from two public databases: the land-use harmonization (LUH2) database (*42*) at 0.25°×0.25° resolution for all years at the landscape scale, and the ESA CCI (*43*) database (900 × 900 m resolution for 1992–2015 for the local scale. For both databases, we extracted the cover of urban land and crop land of the first and last year of sampling. We reprojected the LUH2 to the Eckert IV equal-area map projection and extracted the raster values intersecting with the coordinates of the sites. From the ESA CCI dataset, we calculated the percent urban cover (category 190) and crop cover (categories 10, 11, 12, 30 and 40) over 9 cell squares at and surrounding each site at the end of the sampling period. Categories 30 and 40 are mixed cropland and natural vegetation, and were therefore down-weighted to 0.75*number of cells of category 30 and 0.25* number of cells of category 40. Sites where sampling ended before 1992 were excluded from this analysis. The LUH2 and ESA CCI datasets thus provided similar metrics at different spatial scales to test whether local and landscape land-use was important for insect abundance trends.

Using these data, we tested 1) for relations between the spatial pattern of land-use (percentage crop and urban cover at the end of the sampling period) and trends in insect abundances, and 2) for relations between the changes in spatial patterns of land-use (change in urban and crop cover during the sampling period) and trends in insect abundances. The latter was only tested using LUH2 since at the local scale only 5% of the cells changed in status during the sampling periods.

We also tested for associations between insect abundance trends and climate change, specifically changes in mean monthly temperature and precipitation at regional scales (CRU database (*44*) at 0.5° × 0.5° resolution for all years), and at local scales (CHELSA database (*45*) at 1 km^2 resolution for 1979-2013, 693 sites). The local scale (CHELSA) temperature and precipitation data were obtained as the mean of the nine pixels surrounding each site, and the landscape scale (CRU) data were averaged over 1 to 3 cells, depending on whether the site was located at the center or edge of each grid cell. For both datasets, we calculated the change in monthly mean temperature and precipitation over the sampled period using generalized additive models, accounting for seasonal patterns within a spline term on month. We standardized the estimated mean temperature slope to units change in degrees K per decade. We obtained relative climate change values by dividing these decadal change values by the mean absolute temperature and precipitation (mm) for each site. Because of a lack of water temperature data, and because air and freshwater temperatures are correlated, we used air temperature also for the freshwater datasets.

Statistical analyses

We used autoregressive mixed effects models to assess trends in insect assemblage size (measured as abundance or biomass), and to test whether these temporal trends differed among realms (freshwater or terrestrial), unit (abundance or biomass), continents, capture strata, climatic zones, and with different global change drivers.

By focusing only on the temporal slopes, we could account for vastly different scales of measurement (from less than 1 to billions of insects per sampling unit) and could include datasets measuring biomass and abundance in one model. For the 14 datasets reporting both abundance and biomass, we only included the abundance data in the main models (except the model testing for differences between the two units), to optimize comparability. The data were $\log_{10}N+1$-transformed for analysis, so that all slopes can be interpreted as a percentage change per time-unit. We accounted for the non-independence of repeated measurements at each site and the expected auto-correlation among sites part of the same study by including several nested levels of random effects.

We included a series of random intercepts for:

- dataset
- study area (in cases when sites were clustered in different study areas of the same dataset)
- site (the smallest reported sampling unit)
- within-year time-period (finest resolution: month; when samples were collected repeatedly within year, nested within dataset).

We included random slopes for:

- the effect of year (at the levels of dataset, study area and site)
- temporal autocorrelation by adding an autoregressive term of order 1 (AR1), on which we placed a random effect at the site-level to allow site-level variation in the strength of autocorrelation.

We obtained separate slope estimates for each level of our fixed effects, by setting separate contrasts for the interactions of each of these covariates with time (i.e. Year: Realm: Continent). The continuous explanatory variables were fitted in a similar way, but we tested the for each realm separately to aid interpretability (i.e. year: Urban cover + Year : Crop cover). These continuous explanatory variables were all scaled (divided by the standard deviation) and centered on zero to improve fit and allow comparison of effect sizes. We tested the following models:

- Year (only used to extract the random slopes of each study and site)
- Realm + Year: Realm
- Realm + Unit + Year: Realm: Unit (including biomass data for 14 datasets that reported both units. Note that here all levels of random effects here had separate factors for each dataset/unit combination, to prevent conflicts due to different scales of measurement within dataset that presented both units)
- Realm + Continent + Year: Continent: Realm
- Realm + Climatic zone + Year: Climatic zone: Realm
- Realm + Region + Year: Region: Realm
- Realm + Stratum + Year: Stratum: Realm
- Realm + Protection status + Year: Protection status: Realm

Driver models (all continuous variables, except year, centered to a mean of 0 and scaled to a standard deviation of 1):

- Landscape land-use change model: Year + Urbanization + Change in crop cover + Year: Urbanization + Year: crop cover Change– over sampling period (25 km grid), separate models for each realm
- Landscape land cover model: Year + Urban cover + Crop cover + Year: Urban cover + Year: Crop cover– at end of sampling period (25 km grid), separate models for each realm
- Local land cover model: Year + Urban cover + Crop cover + Year: Urban cover + Year: Crop cover– at end of sampling period (0.81 Km grid), separate models for each realm
- Landscape climate change model: Year + Relative $\Delta_{\text{Temperature}}$ + Relative $\Delta_{\text{Precipitation}}$+ Year: Rel. $\Delta_{\text{Temperature}}$ + Year: Rel. $\Delta_{\text{Precipitation}}$ – at end of sampling period (50 km grid), separate models for each realm
- Local climate change model: Year + Relative $\Delta_{\text{Temperature}}$ + Relative $\Delta_{\text{Precipitation}}$+ Year: Rel. $\Delta_{\text{Temperature}}$ + Year: Rel. $\Delta_{\text{Precipitation}}$ – at end of sampling period (1 km grid), separate models for each realm

To test whether the trends changed over time, we applied the model for continents and realms on progressively shorter time frames: since 1960 (almost the full dataset), since 1970, 1980, 1990, 2000 and since 2005. For each time slice, we excluded all data before the cut-off year, and all sites that had a duration of less than 9 years within the time slice. We plotted only those estimates with 4 or more datasets or more than 20 sites per continent.

The general model framework including these fixed and random effects can be written as:

$$x_{i,t} = ß_0 Realm_i + ß_O Unit_i + ß_1(Realm_i + Unit_i)\, Year_t + \\ \left(ß_1 + ß_{1\,plot[i]}\right) x_{i,t-1} +$$

$$ß_{0\ dataset[i]} + ß_{0\ study\ area[i]} + ß_{0\ plot[i]} + ß_{0\ period[i]} +$$
$$\left(ß_{1\ dataset[i]} + ß_{1\ study\ area[i]} + ß_{1\ plot[i]}\right) Year_t$$
(eqn. 1)

Where x is $\log_{10}$ abundance or biomass+1; t is a given year and i is a site (within a given time-period, study area and dataset). $ß_0$ represent intercepts and $ß_1$ represent slopes. The model assumed that $x_{i,t}$ was normally distributed. The top row of the equation shows the fixed effects; the second row shows the temporal autocorrelation (and site-level variation in it) and the bottom two rows show the random intercepts and slopes, respectively.

We fitted these models using Integrated Nested Laplace Approximation (INLA) (*46*) in R 3.5.2(*47*), a Bayesian method that efficiently and accurately approximates Bayesian posterior distributions (*48*), without using MCMC, and which allows for complex layered random effects, including autoregressive terms.

We used the default INLA priors for all parameters. These are uninformative normal priors with mean = 0 and large variance (1000) for the fixed effects (intercept and slopes), assuming no prior information or belief about the individual trends and their distribution. Gamma (shape = 1, inverse scale = 0.00005) distributions were used for the precision (inverse variance) of the random effects, applied on the log-scale within INLA (*49*), which leads the prior for the precision to be a simple exponential distribution. The prior for the AR1 correlation is defined by INLA on the logit lag one correlation scale ($log\left(\frac{1+\rho}{1-\rho}\right)$ where ρ is the correlation coefficient) and was given a normal prior (mean=0, precision=0.15). In the main text, we present the results of the analysis using these mostly uninformative priors but we ran a sensitivity analysis to prior choice (see below).

The general model structure in INLA annotation is:

```
inla(x ~ Year: Realm: U + Realm + U +
    f(Period, model='iid')+                  # random intercept season
    f(Plot_ID, model='iid')+                 # random intercept site
    f(StudyArea_ID, model='iid')+            # random intercept study area
    f(Datasource_ID, model='iid')+           # random intercept study
    f(Plot_ID_slope, iYear, model='iid')+    # random slope site
    f(StudyArea_ID_slope, iYear, model='iid')+   # random slope study area
    f(Datasource_ID_slope, Year, model='iid')+    # random slope study
    f(Year,model='ar1', replicate=as.numeric(Plot_ID))# AR1 term
    family="gaussian"                                 # normal distribution
```

Where x = $\log_{10}$ abundance or biomass+1, and U = any covariate (unit, continent, climatic zone, capture stratum, protection status or global change drivers).

We report the parameter estimates in the main text as percent change per year, as calculated from the slope in $\log_{10}$ space, similar to (*10*) (e.g. a slope of -0.0041 per year in $\log_{10}$ space= 0.9905 ($10^{-0.0041}$) = -0.0094 per year (1-0.9905) = -0.94% (-0.0094*100) per year). To make this number more tangible, we provide the percentage change per decade for the mean findings. This was calculated as the percentage change observed after 10 timesteps, in comparison to the first observation. (e.g. ($10^{(-0.0041*10)}$-1) *100).

Model checking

- We tested for effects of confounding effects of start year, end year and duration of each time-series, but only found no evidence for confounding effects (effect sizes of all estimates were <0.0001, and in all cases the chance that the mean estimate was larger or smaller than zero was less than an 80%.
- We checked plots of the relationship between observed data and model predictions and found a good correlation for most continents (Fig. S7).
- We also checked the model's goodness of fit using the probability integral transform (PIT) (*50*). PIT measures the probability of a new value to be lower than the actual observed value using a model based on the rest of the data. PIT values should follow a uniform distribution if the model assumptions are correct. The PIT check suggested no major problems with model fit.
- Random effects: The random effects (intercepts and slopes) assume that deviations of the different levels within each group (sites, study areas, studies etc.) from the overall mean can be modelled as a normal distribution with mean 0. As in a standard mixed-effects models, the standard deviations of these distributions are estimated by the model. Effects with larger standard deviations indicate groups with large variation among different units. Standard deviations of the random effects are reported in Table S3 and show that most variation for both the intercepts and the slopes was contained at the study level, and that all other levels also contain variation.

Sensitivity tests

Priors

To check the sensitivity of the results to prior specification, we also ran the Realm model with penalized complexity (PC) priors, which have recently been recommended for INLA (*51*). PC priors are weakly informative priors in that they penalize departures from a simpler based model on the principle of parsimony (*50*).

For random effects, this means using an exponential distribution for the prior on the standard deviation (σ) of the random effect, which means putting greater confidence in smaller values. This requires specifying some scaling for which we followed a common rule of $P(\sigma > 3 * \text{sd(response data)}) = 0.01$, using INLA's pc.prec function. For the strength of the autocorrelation in the prior of the AR1 term (ρ) we tested several values: we tested that there was a 0.75 probability that the auto-correlation between consecutive years was larger than 0.5, 0.6 and 0.86 (i.e. $P(\rho > 0.86) = 0.75$), using INLA's pc.cor1 function.

The models run with the PC prior produced almost identical results as the main model, with less than 3% difference between the mean estimates of the PC-prior models and the main model. Hence, our results show some robustness to the specification of the prior.

Outliers

We also checked three models (Realm, Continent and Climatic zone as covariates) for sensitivity to outliers, by running the same model, but excluding 14 datasets that had random slopes outside 1.5 the interquartile distance above or below the quartiles of all random slopes.

For the Realm model, the exclusion of outliers reduced the effect sizes for both realms (terrestrial: -0.66%; freshwater +0.33% per year), but there was still strong evidence for a decline of terrestrial fauna. For the freshwater, however, there was now no evidence for an increase (terrestrial CI: -1.26%–-0.04% p = 0.981; freshwater: -0.42%–+1.12% per year, p = 0.196). Since most of these outlying datasets originated from North America, there was no evidence for a directional trend in either realm in this continent (terrestrial: p = 0.893, freshwater p = 0.143). By contrast, there was now strong evidence for a decline of the European terrestrial insect abundances (p = 0.983). For the Australian, or rather New Zealand's freshwater fauna, as the only remaining dataset, there was now weak evidence for a decline (p = 0.914). The strength of evidence for, and direction of, trends for the other continents did not change. In the model for climatic zones excluding outliers, the evidence for a decline for the temperate terrestrial insects remained strong (p = 0.995), but there was no longer evidence for a trend for the freshwater realm (p = 0.257. The evidence for directional trends in the drylands was now strong in both realms. This shows some overall sensitivity to extreme values in the data, which in most cases reduced the effect sizes, as well as the certainty of the estimates. However, all of these datasets classified as outliers were large, datasets with high temporal resolution and spatial replication, with which long-term trends could be estimated with high confidence. Hence, we regarded them as supplying important information on insect trends and based on our main interpretation on the models that include them. The datasets classified as outliers were: DataSource_ID's: 70, 313, 1006, 1261, 1364, 1408, 1423, 1427, 1476, 1477, 1478, 1493, 1503. See table S1 and (*36*) for more details.

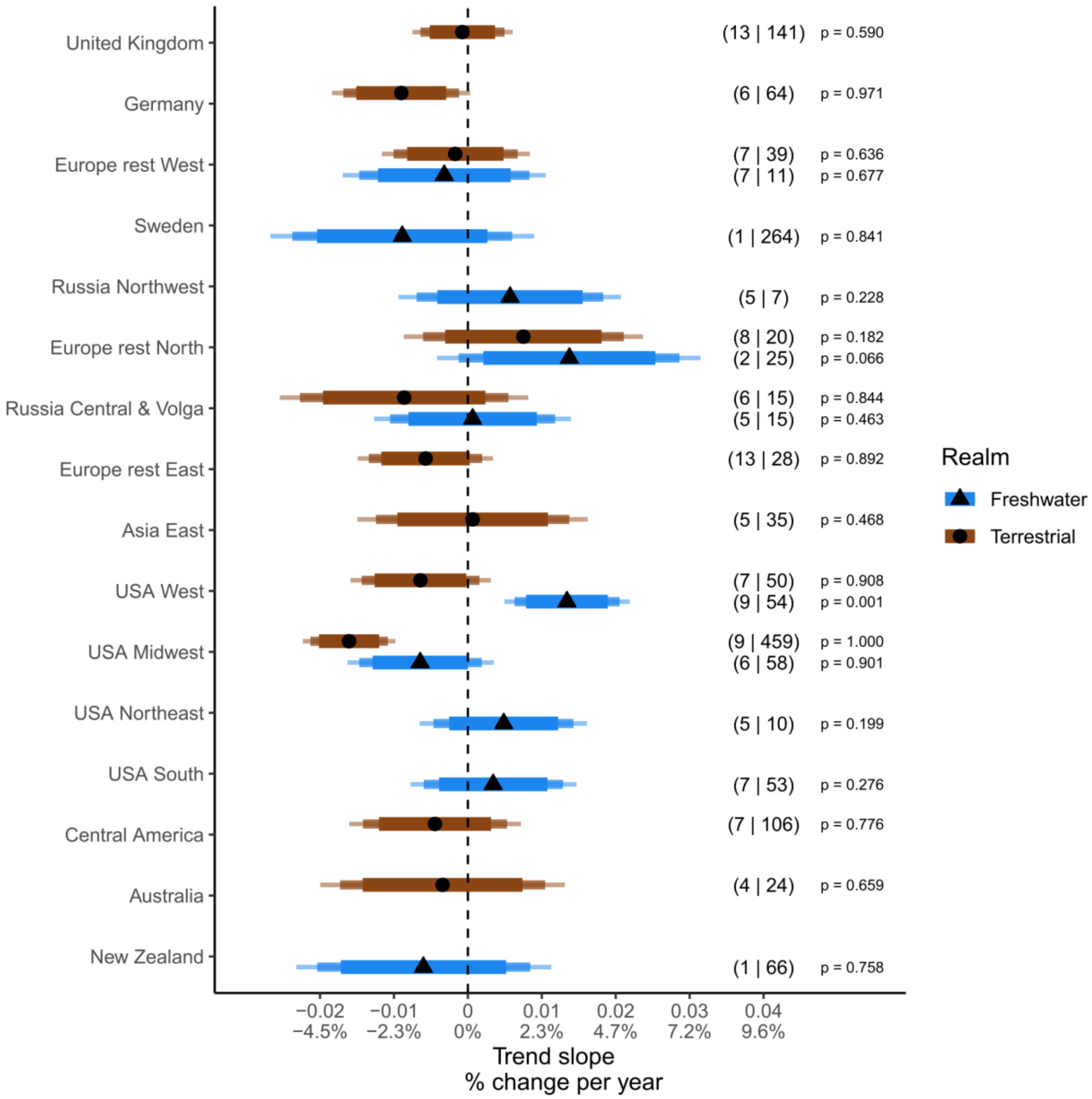

Fig. S1. Trend estimates (±80, 90, and 95% credible intervals) for countries and geographic regions.

Only estimates with at least either five independent datasets, or 20 or more sites are included. Missing bars in any region or country indicate insufficient data. In the cases of Germany and United Kingdom, the freshwater datasets were grouped under Europe rest West, and terrestrial data from Russia Northwest were grouped with Europe rest North.

The bracketed numbers represent the number of datasets and the number of sites respectively underlying each estimate. The p-values represent the posterior probability that the estimated parameter is smaller than zero (one-tailed). For example, a probability of 0.975 corresponds to a 95% likelihood of the mean parameter being smaller than zero, and a probability of 0.1 corresponds to an 80% probability that the estimate is larger than zero.

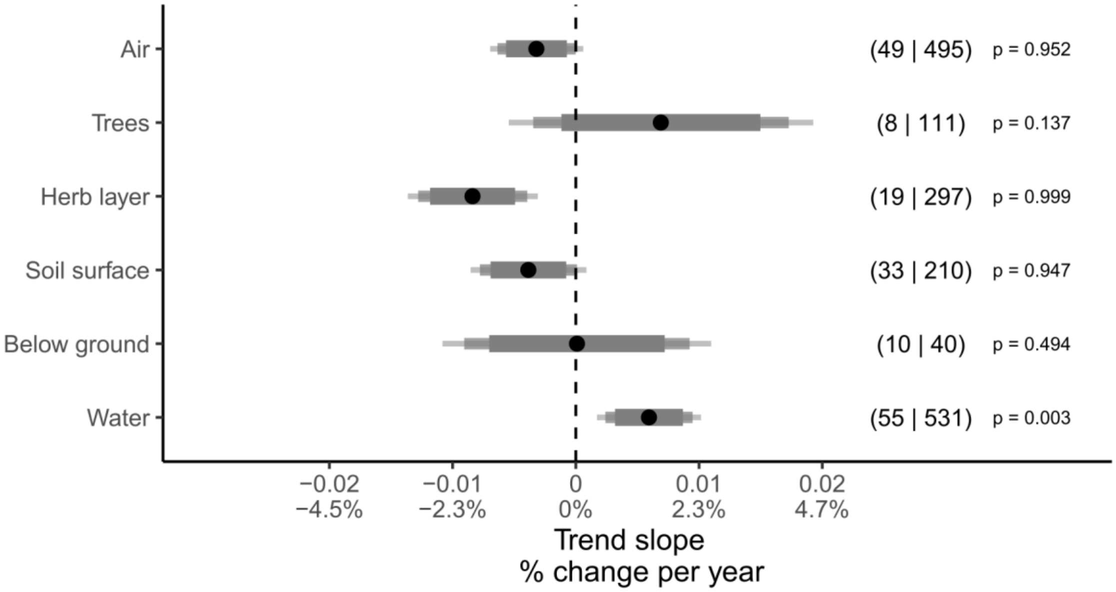

Fig. S2. Trend estimates (±80, 90 and 95% credible intervals) in insect abundance and biomass for insects sampled in different strata.

The data were grouped according to sampling method: Aerial sampling included observation transects (Pollard walks), suction pipes, light traps, malaise traps, window traps and pan traps; the tree layer data included arboreal window traps, visual counts and sticky traps; the herb layer included sweep-net transects, suction sampling, sampling rings, and visual counts; the soil surface included pitfall traps and ant nest counts; underground insects were sampled in soil cores; water included: Peterson-, Eckman-, Hess-, Surber-, Apstein samplers, Kicksamplers, suction sampling, T-sampler, sampling baskets, artificial substrate and aquatic emergence traps. Note that ‘water’ contains fewer datasets than ‘Freshwater’ in the Realm analysis due to dragonflies and mosquitoes being sampled in flight. Annotation as in Fig S1.

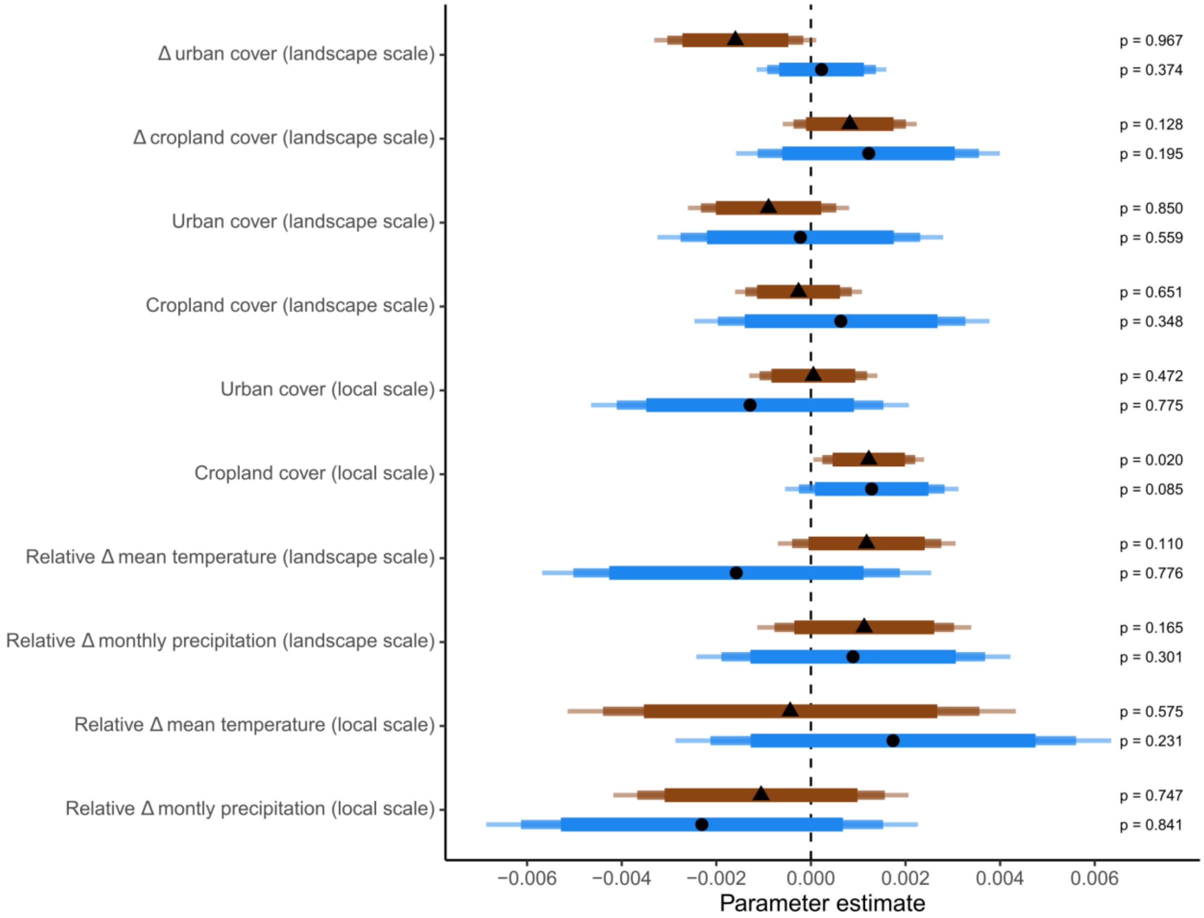

Fig. S3. Trend estimates of global change drivers.

Model estimates (±80, 90, and 95% credible intervals) of the interaction between the year and each global change driver in models separately calculated for each realm. Negative estimates thus indicate more negative trends with higher values of the driver, and positive estimates vice versa. Land use data at the landscape scale (c. 25 km grid area) were derived from the LUH2 database, and land use data at 0.81 km^2 were obtained from the ESA CCI database. Climate data at the landscape scale (c. 50 km grid) were obtained from CRU, and data at 1 km^2 were obtained from CHELSA. The static values of land-cover percentages represent the land-cover percentage at the end of the sampling period for each site. All variables were scaled to a mean of 0 and a standard deviation of 1 to improve the comparability among variables. Annotation as in Fig. S1.

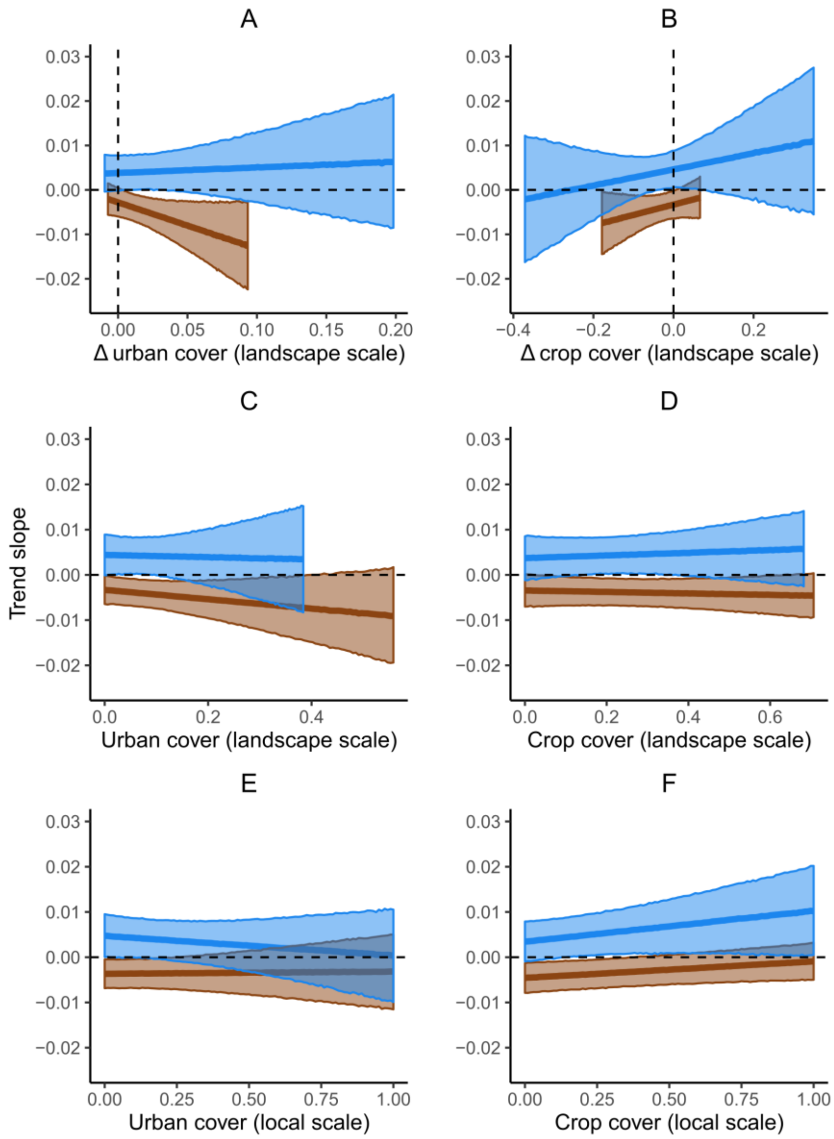

Fig. S4. Modification of the insect abundance trends by anthropogenic land use (±95% credible intervals).

Anthropogenic influence was measured as [i] change in urban (a) and cropland (b) cover over the sampling period for each site, [ii] landscape scale urban (c) and cropland cover (d) (c. 25 km grid) at the end of the sampling period, and [iii] local urban (e) and cropland cover (f) (0.81 km^2) at the end of the sampling period (only available for sites that were sampled until at least 1992. There was moderate evidence for a negative association between terrestrial insect abundance trends and landscape-scale urbanization (a), strong evidence for a positive association between terrestrial trends and local crop cover (f), and weak evidence for a positive association between freshwater trends and local crop cover (f). 95% credible intervals were calculated from 10 000 random draws for each of 100 values along each land-use gradient. The draws were taken from a normal distribution with means and standard deviations derived from the model estimates.

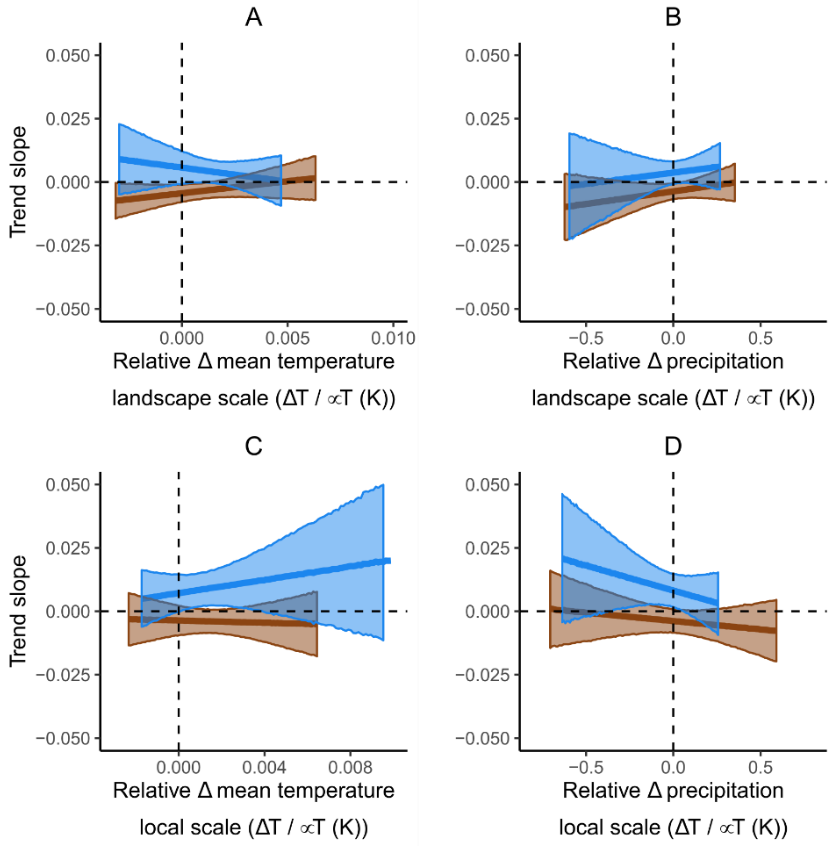

Fig. S5. Modification of the insect abundance trends by anthropogenic drivers (±95% credible intervals) by relative changes in mean temperature (a,c) and precipitation (b,d) at landscape (a,b) and local scales (c,d).

None of the climatic variables tested here showed evidence for an interaction with temporal slope of insect abundances (see Fig S3). Landscape scale: ca. 50 km grid; local scale: 1 km^2 grid, only for datasets within the 1979-2013 period). Credible intervals were calculated as in Fig S4.

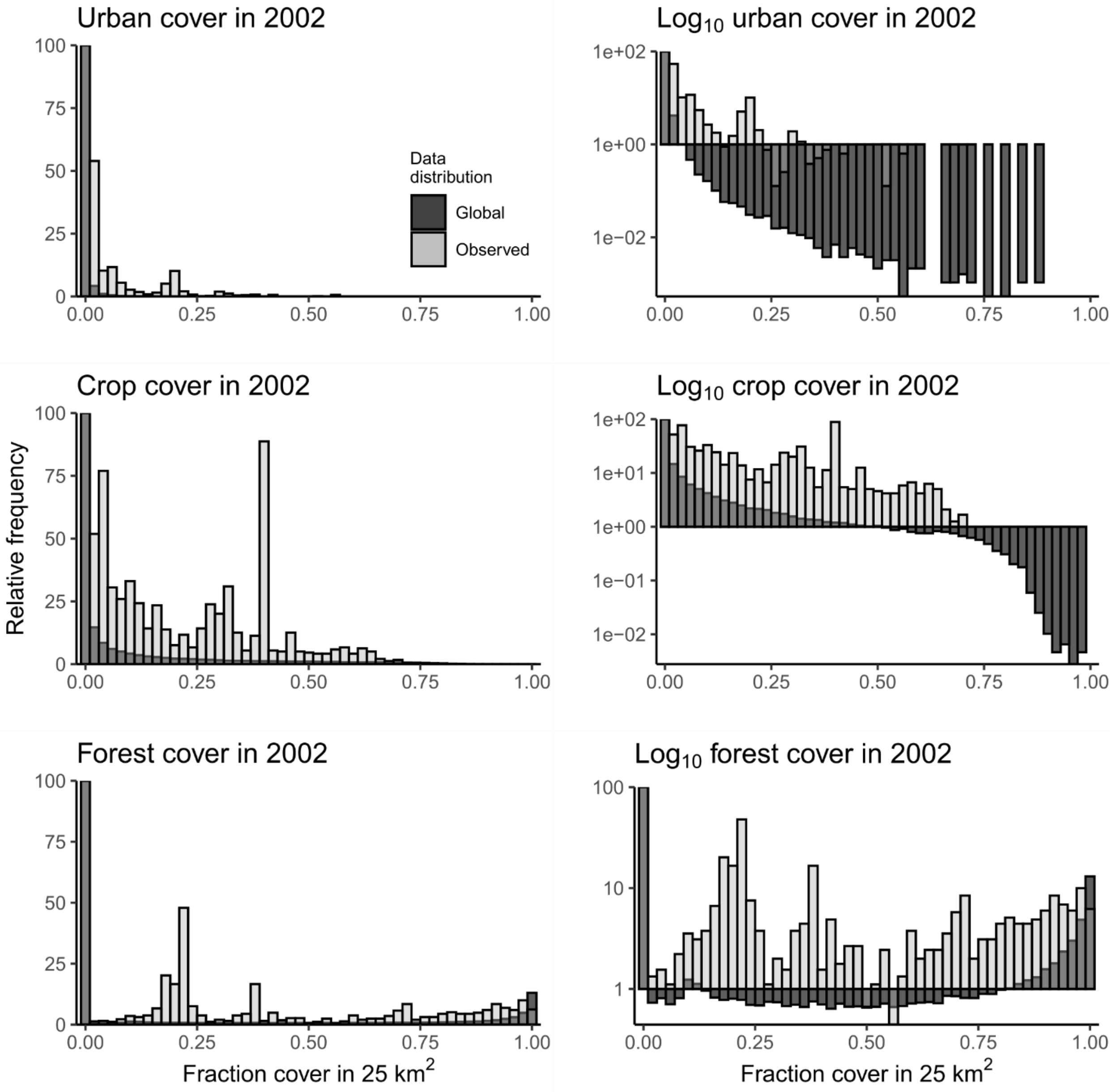

Fig. S6. Histograms of the fractions of urban, crop and forest cover per 25 km^2 globally and observed in our data.

Global fractions were obtained from all terrestrial pixels of the LUH2 database *(45)* for the median year of all observations (2002). The counts per bin were scaled to the maximum observed count to ensure comparability. Thus, the observed values represent deviations from the global values if the most common bin had been sampled representatively. The second column shows the same values in log space to improve visibility of very low frequencies.

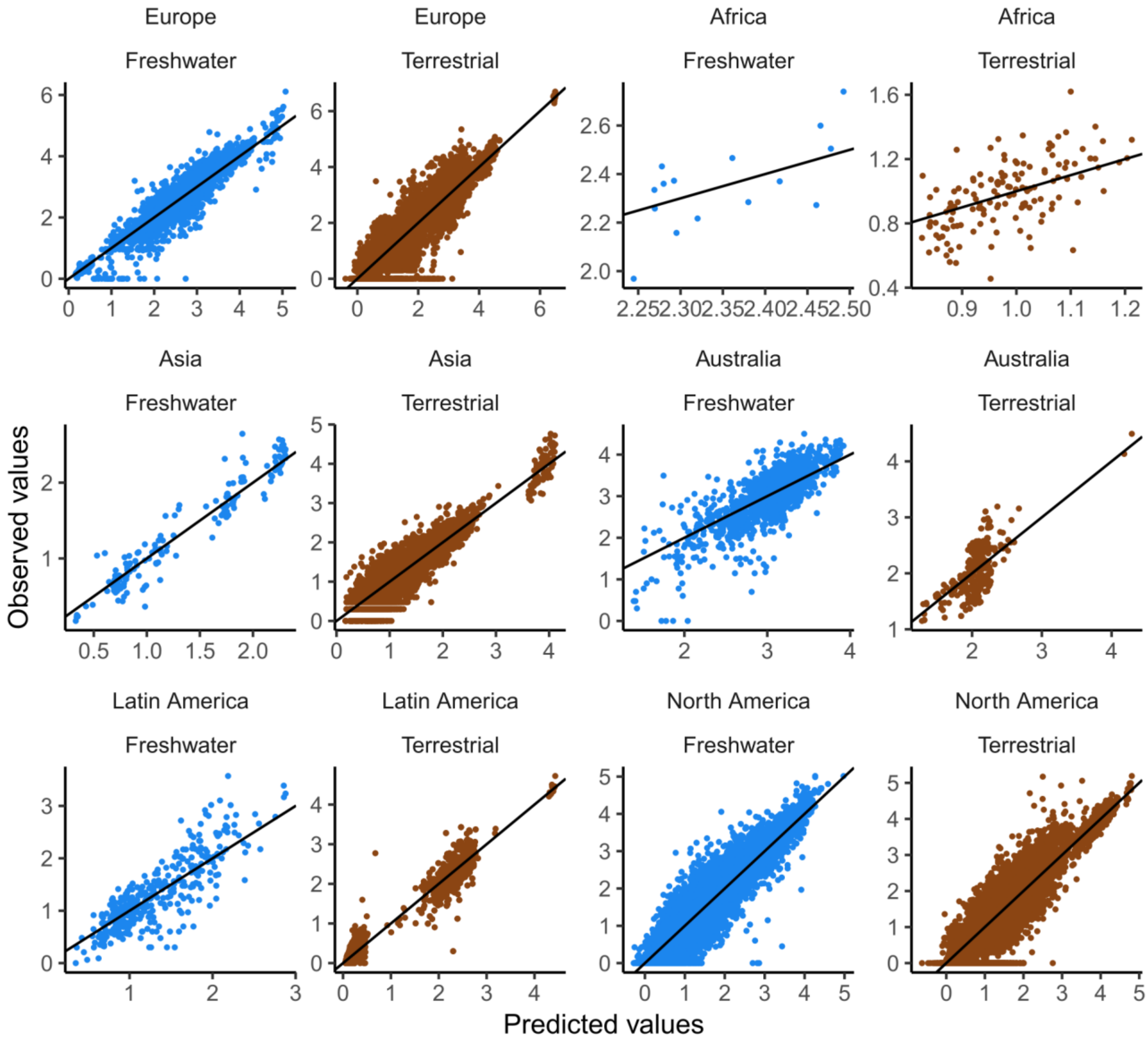

Fig. S7. Correlation between the predicted and observed values of the hierarchical Bayesian model for realms and continents.

Table S1. Details on the datasets used in this study.

More detailed metadata are available in the data repository on the Knowledge Network Biocomplexity (*36*).

Open access licenses:

- **PD**: public domain (all data extracted from papers),
- **OGL**: Open Government License (UK),
- **CC-BY, CC0, CC-BY-NC, CC-BY-ND**,
- **ODC**: Open Data Commons
- **no shar**: data openly accessible, but no redistribution of data or derived products is allowed,
- **private**: data are not publicly accessible, but the derived numbers are available in Data S1 and on KNB (*36*).

Guide to vernacular names of the taxa: **Dragonflies** – Odonata; **Butterflies** – Lepidoptera: Papilionoidea; **Grasshoppers** – Orthoptera: Caelifera (in some cases also Ensifera); **Beetles** – Coleoptera; **Moths** – night-active Lepidoptera; **Aphids** – Hemiptera: Sternorrhyncha: Aphidoidea; **Ground beetles** – Coleoptera: Carabidae; **Ants** – Hymenoptera: Formicidae; **Froghoppers** – Hemiptera: Auchenorrhyncha: Aphrophoridae; **Plant- and leafhoppers** – Hemiptera: Auchenorrhyncha; **Spiders** – Araneae; **Hoverflies** – Diptera: Syrphidae; **Ladybeetles** – Coleoptera: Coccinellidae; **Orchid bees** – Hymenoptera: Apidae: Euglossini; **Non-biting midges** – Diptera: Nematocera: Chironomidae; **Dung beetles**: Coleoptera: Scarabaeoidea; **Carrion beetles** – Coleoptera: Silphidae; **Springtails**: Collembola; **Parasitoid wasps** – parasitoid families of the Hymenoptera; **Saproxylic beetles** – dead-wood feeding Coleoptera; **Mayflies** – Ephemeroptera; **Rove beetles** – Coleoptera: Staphylinidae; **Bumblebees** – Hymenoptera: Apidae: Bombini; **Bugs** – Hemiptera: Heteroptera and Auchenorrhyncha; **Sawflies**: Hymenoptera: Symphyta; **Mosquitoes** – Diptera: Nematocera: Culicidae.

Datasource ID	Place	Taxon	Abundance/ Biomass	Start	End	Time span (yrs)	Nr yrs data	Nr of sites	link	Access license	Reference
63	UK: England	Dragonflies	A	1959	1988	30	29	1		CC-BY	(*37*)
70	Belgium	Migratory Lepidoptera	A	1983	1996	14	14	1		CC-BY	(*37*)
79	United Kingdom	Butterflies	A	1976	1989	14	14	30		CC-BY	(*38*)
249	Denmark	Coleoptera and Lepidoptera	A	1992	2015	24	24	1	Dryad	CC0	(*52*)
294	Vietnam	Butterflies	A	2003	2013	11	8	6		CC-BY	(*37*)
300	USA: Michigan	Insects	A	1989	2017	29	29	51	URL	CC-BY	(*53*)
301	USA: Kansas	Grasshoppers	A	1982	2013	32	25	15	URL	CC-BY	(*54*)
313	USA: Minnesota	Grasshoppers	A	1989	2006	18	18	20	URL	CC-BY	(*55*)
375	Japan	Beetles	AB	2004	2014	11	11	22		CC-BY	(*37*)
380	UK: England	Butterflies	A	1978	1987	10	10	1		PD	(*37*)
465	Czech republic	Moths	A	1967	1992	26	26	1		PD	(*38*)
478	Germany	Freshwater invertebrates	A	1969	2005	37	37	5	URL	CC-BY	(*56*)
502	United Kingdom	Aphids	A	1969	1990	22	22	16		PD	(*38*)
1006	United Kingdom	Moths	A	1992	2015	24	24	13	URL	OGL	(*57*)
1102	Netherlands	Ground beetles	A	1959	2016	58	50	29		Private	(*58*, *59*)
1261	USA: Massachusetts	Ants	A	2003	2015	13	8	13	URL	CC-BY	(*60*)
1263	United Kingdom	Butterflies	A	1993	2012	20	20	13	URL	OGL	(*61*)
1266	United Kingdom	Froghoppers	A	1993	2015	23	23	16	URL	OGL	(*62*)
1267	United Kingdom	Ground beetles	A	1993	2015	23	23	36	URL	OGL	(*63*)
1310	Panama	Plant- and leafhoppers	A	1974	1987	14	14	1		PD	(*64*)
1312	Czech republic	Moths	A	1963	1991	29	29	3		PD	(*65*)
1319	New Mexico	Grasshoppers	A	1992	2013	22	22	4	URL	CC-BY	(*66*)
1324	Netherlands	Spiders and Ground beetles	A	1969	2008	40	39	4		PD	(*67*)
1328	UK: England	Hoverflies	A	1972	2001	30	30	1		Private	(*68*)
1335	Czech republic	Ladybeetles	A	1983	2010	28	2	3		PD	(*69*)
1339	USA: Montana	Grasshoppers	A	1981	2016	36	36	4	URL	No shar	(*70*)
1340	Hungary	Moths	A	1962	2009	48	46	7	Dryad	CC0	(*7*)
1345	USA: New Mexico	Ground dwelling arthropods	A	1992	2004	13	13	3	URL	CC-BY	(*71*)
1346	USA: New Mexico	Ants	A	1995	2005	11	11	6	URL	CC-BY	(*72*)
1347	USA: Wisconsin	Freshwater invertebrates	A	1981	2015	35	33	14	URL	CC-BY	(*73*)
1349	USA: Arizona	Ground dwelling arthropods	A	1998	2016	19	19	29	URL	CC-BY	(*74*)
1351	USA: Arizona	Freshwater invertebrates	A	1985	1999	15	10	1	URL	CC0	(*75*)
1353	USA: Arizona	Ants	A	1988	2009	22	19	2	URL	CC0	(*76*)
1357	Puerto Rico	Arboreal arthropods	A	2004	2016	13	6	34	URL	CC-BY	(*77*)
1361	USA: Georgia	Grasshoppers	A	2000	2016	17	17	8	URL	CC-BY	(*78*)
1364	USA: Minnesota	Herb layer arthropods	A	1996	2006	11	10	172	URL	CC-BY	(*79*)

1365	USA: Minnesota	Ground beetles	A	1980	2005	26	2	3	URL	PD	(*80*)
1367	Italy	Ground beetles	A	1980	2009	30	4	6		PD	(*81*)
1376	Taiwan	Freshwater invertebrates	A	1985	1995	11	2	4		PD	(*82*)
1377	Panama	Orchid bees	A	1979	2000	22	20	1		PD	(*83*)
1378	Costa Rica	Butterflies	A	2003	2012	10	10	1		PD	(*84*)
1379	Ecuador	Butterflies	A	1994	2004	11	11	1		PD	(*85*)
1381	Brazil: Rio Grande del Sul	Non-biting midges	A	2000	2010	11	10	1		PD	(*86*)
1382	Chile	All arthropods	AB	2003	2014	12	12	1		PD	(*87*)
1384	New Zealand	Moths	A	1962	1988	27	2	1		PD	(*88*)
1385	Brazil: Amazonas	Dung- and Carrion beetles	A	1986	2000	15	2	4		PD	(*89*)
1387	Australia	Spiders	A	1990	2000	11	7	1		PD	(*90*)
1388	USA: California	Freshwater invertebrates	A	1984	2003	20	20	4	URL	PD	(*91, 92*)
1391	Russia: Murmansk	Soil fauna	A	1986	2010	25	3	6		PD	(*93*)
1392	Slovakia	Butterflies	A	2001	2012	12	6	1		PD	(*94*)
1393	Russia: Tatarstan	Insects	A	1978	1995	18	18	3		PD	(*95*)
1394	Uganda	Butterflies	A	2000	2011	12	12	1		PD	(*96*)
1395	West Africa	Freshwater invertebrates	A	1984	1998	15	15	1		PD	(*97*)
1396	Germany	Springtails	A	1980	2000	21	17			PD	(*98*)
1397	Hungary	Ants (nests)	A	1981	2017	37	28	1		PD	(*99*)
1398	Czech Republic	Beetles	A	1975	2007	33	7	3		PD	(*100*)
1400	Russia: Buryatia	Ground beetles	A	1988	2007	20	20	4		PD	(*101*)
1401	Russia: Lipetsk Oblast	Beetles	A	1995	2004	10	10	1		PD	(*102*)
1402	Russia: Krasnoyarsk Krai	Springtails	A	1969	2010	42	2	8		PD	(*103*)
1403	Russia: Sverdlovsk Oblast	Parasitoid wasps	A	1994	2003	10	4	1		PD	(*104*)
1404	Greenland	Arthropods	A	1996	2017	22	21	6	URL	No shar	(*105*)
1405	Finland	Saproxylic beetles	A	1990	1999	10	10	2		PD	(*106*)
1406	Russia: Orenburg Oblast	Ground dwelling arthropods	A	1990	2004	15	9	1		PD	(*107*)
1407	Russia: Tver Oblast	Ground beetles	A	1996	2012	17	17	2		PD	(*108*)
1408	Finland	Freshwater invertebrates	A	2000	2013	14	14	23	Dryad	CC0	(*109*)
1409	Germany	Flying Insects	B	1989	2016	28	18	24		PD	(*10*)
1410	Germany	Arthropods	A	1992	2005	14	8	1		PD	(*110*)
1411	Austria	Soil fauna	AB	1998	2012	15	2	4		PD	(*111*)
1412	Netherlands	Freshwater invertebrates	A	1987	2007	21	5	1		PD	(*112*)
1413	South Korea	Soil fauna	A	1998	2007	10	10	8		PD	(*113*)
1414	Iceland	Non-biting midges	A	1977	1996	20	20	2		PD	(*114*)
1415	Wisconsin	Mayflies	AB	2002	2012	11	2	1		PD	(*115*)
1416	USA: New Hampshire	Caterpillars	AB	1986	1997	12	12	4	URL	No shar	(*116*)
1417	USA: Michigan	Freshwater invertebrates	B	1984	1993	10	10	2		PD	(*117*)
1418	USA: Tennessee	Dragonflies	A	1978	1989	12	12	1		PD	(*118*)
1419	Western Australia	Ants	A	1980	1997	18	2	3		PD	(*119*)

1421	USA: Arkansas	Freshwater invertebrates	A	1971	1999	29	2	2		PD	(*120*)
1422	USA: Tennessee	Freshwater invertebrates	A	1986	2003	18	18	4		PD	(*121*)
1423	USA: Colorado	Freshwater invertebrates	A	1989	2006	18	18	4		PD	(*122*)
1424	USA: Wisconsin	Freshwater invertebrates	A	1981	2004	24	21	1		PD	(*123*)
1425	USA: Georgia	Freshwater invertebrates	AB	1956	1991	36	2	1		PD	(*124*)
1426	USA: Pennsylvania	Freshwater invertebrates	A	1980	1990	11	11	3		PD	(*125*)
1427	USA: Idaho	Freshwater invertebrates	AB	1993	2005	13	13	6		PD	(*126*)
1428	USA: Pennsylvania	Freshwater invertebrates	AB	1972	1996	25	7	1		PD	(*127*)
1429	USA: New York	Freshwater invertebrates	A	1956	2016	61	61	2		ODC	(*128*)
1430	USA: Utah	freshwater invertebrates	A	1958	1999	42	28	3		PD	(*129*)
1431	USA: Alaska	Freshwater invertebrates	A	1984	1998	15	15	2		PD	(*26*)
1432	USA: North Carolina	Freshwater invertebrates	B	1992	2006	15	15	1		PD	(*130*)
1433	Belgium	Freshwater invertebrates	A	1998	2011	14	13	1		PD	(*131*)
1434	Switzerland	Spiders	A	1994	2004	11	11	1		PD	(*132*)
1435	USA: Kentucky	Freshwater invertebrates	A	1960	1990	31	2	12		PD	(*133*)
1437	USA: Idaho	Freshwater invertebrates	B	1979	1989	11	11	10		PD	(*134*)
1439	China	Freshwater invertebrates	A	1987	2007	21	2	4		PD	(*25*)
1440	CA: Winnipeg	Freshwater invertebrates	A	1969	2013	45	12	3		PD	(*135*)
1441	CA: Ontario	Freshwater invertebrates	A	1983	1995	13	3	2		PD	(*136*)
1444	New Zealand	Freshwater invertebrates	A	1989	2008	20	20	66	GBIF	CC_BY_NC	(*137*)
1445	USA: Arizona	Ants (nests)	A	1977	2009	33	28	2		CC0	(*76*)
1446	Russia: Kursk Oblast	Ground beetles	A	1983	1999	17	16	3		PD	(*138*)
1448	Russia: Nenets Okurg	Freshwater invertebrates	AB	1990	2000	11	2	1		PD	(*139*, *140*)
1449	Russia: Komi Republic	Freshwater invertebrates	AB	2000	2014	15	5	2		PD	(*141*)
1451	Russia: Perm Krai	Freshwater invertebrates	B	1964	2014	51	12	1		PD	(*142*)
1452	Russia: Perm Krai	Freshwater invertebrates	B	2002	2015	14	6	6		PD	(*143*)
1453	Russia: Karelia	Freshwater invertebrates	AB	1954	1993	40	16	1		PD	(*144*)
1454	Russia: Karelia	Freshwater invertebrates	B	2003	2015	13	13	1		PD	(*145*)
1455	Russia: Nenets Okurg	Freshwater invertebrates	AB	1968	2010	43	6	1		PD	(*140*, *146*)
1456	Russia: Saratov Oblast	Freshwater invertebrates	AB	1969	2011	43	6	3		PD	(*147*, *148*)
1457	Russia: Samara Oblast	Freshwater invertebrates	AB	1991	2007	17	6	3		PD	(*149*)
1458	Russia: Novgorod Oblast	Springtails	A	1981	1995	15	5	3		PD	(*150*)
1459	Russia: Moscow Oblast	Ground beetles	A	1974	1990	17	6	2		PD	(*151*)
1460	Russia: Leningrad Oblast	Rove beetles	A	1983	2005	23	4	1		PD	(*152*)
1461	Russia: Khabarovsk Krai	Hoverflies	A	1988	2013	26	5	1		PD	(*153*)
1462	Russia: Primorsky Krai	Butterflies	A	1986	2005	20	20	1		PD	(*154*)
1464	Belarus	Hymenoptera	A	1990	2000	11	11	1		PD	(*155*)
1465	Malaysia	Moths	A	1965	2007	43	2	10		PD	(*156*)

1466	Kazachstan	Freshwater invertebrates	B	1939	2012	74	48	1		PD	(*157*)
1467	Belarus	Hymenoptera	A	1986	2003	18	16	1		PD	(*158*)
1468	Spain	Bumblebees	A	1988	2008	21	2	1		PD	(*159*)
1470	Belarus	Hymenoptera	A	1985	2005	21	21	1		PD	(*160*)
1471	Ukraine	Beetles	A	2003	2011	9	9	1		PD	(*161*)
1472	Hungary	Moths	A	1990	2004	15	8	1		PD	(*162*)
1473	Idaho	Freshwater invertebrates	AB	1993	2013	21	19	11		PD	(*163*, *164*)
1474	Germany	Bugs and Grasshoppers	A	1951	2009	59	2	9	URL	CC-BY-ND	(*165*, *166*)
1475	Germany	Plant- and leafhoppers	A	1962	2010	49	9	27	URL	CC-BY-ND	(*9*, *166*)
1476	USA: Wisconsin	Butterflies	A	1987	2017	31	31	56		private	(*167*)
1477	USA: Wisconsin	Butterflies	A	1988	2017	30	30	47		private	(*167*, *168*)
1478	USA: Wisconsin	Butterflies	A	1990	2017	28	28	35		private	(*168*)
1479	AUS: Tasmania	Ground dwelling arthropods	A	1999	2015	17	9	6		private	(*169*)
1480	AUS: Tasmania	Ground dwelling arthropods	A	2001	2012	12	4	14		private	(*170*)
1481	Israel	Butterflies	A	2009	2018	10	10	10		private	(*171*)
1484	Mexico	Herb layer arthropods	B	1987	2014	28	3	1		PD	(*11*)
1485	Puerto rico	Herb layer arthropods	B	1976	2013	38	5	3		PD	(*11*)
1487	Puerto rico	Canopy arthropods	A	1991	2016	26	15	65		PD	(*172*)
1488	Sweden	Freshwater invertebrates	AB	1969	2017	49	48	361	URL	CC0	(*173*)
1491	Brazil: Minas Gerais	Freshwater invertebrates	A	1999	2010	12	12	13	GBIF	CC-BY-NC	(*174*, *175*)
1493	UK: England	Flying Insects	AB	2000	2009	10	10	1		PD	(*176*)
1494	UK: England	Sawflies	A	1970	1988	19	19	5		PD	(*177*)
1495	United Kingdom	Flying Insects	B	1973	2001	29	29	4		PD	(*178*)
1496	UK: Scotland	Flying Insects	AB	1972	1997	26	26	1		PD	(*179*)
1497	UK: England	Ladybeetles	A	2006	2016	11	11	4		PD	(*180*)
1498	Ireland	Freshwater invertebrates	A	1985	1998	14	12	1		PD	(*181*)
1499	UK: Scotland	Freshwater invertebrates	A	1983	1994	12	12	1		PD	(*182*)
1500	UK: Wales	Freshwater invertebrates	A	1981	2005	25	21	1		PD	(*183*)
1501	Ireland	Butterflies	A	1992	2016	25	17	2	GBIF	CC-BY	(*184*)
1502	China	Ground beetles	A	1997	2014	18	2	3		PD	(*185*)
1503	Australia: New South Wales	Freshwater invertebrates	A	1980	2012	33	32	6		PD	(*186*)
1504	USA: California	Freshwater invertebrates	A	1998	2015	18	18	6		PD	(*187*)
1505	Finland	Mining and galling insects	A	2003	2013	11	11	1	Dryad	CC0	(*188*, *189*)
1506	Costa Rica	Freshwater invertebrates	AB	1997	2011	15	15	2		PD	(*190*)
1507	Russia: Orenburg Oblast	Freshwater invertebrates	AB	1981	2005	25	6	1		PD	(*191*)
1508	Russia: Murmansk Oblast	Freshwater invertebrates	AB	1992	2005	14	2	4		PD	(*192*, *193*)
1509	Russia: Murmansk Oblast	Freshwater invertebrates	AB	1939	2010	72	8	2		PD	(*194*)

1510	Russia: Archangelsk Oblast	Freshwater invertebrates	AB	2003	2015	13	13	1		PD	(*195*)
1511	Russia: Novosibirsk Oblast	Freshwater invertebrates	B	1925	2004	80	19	1		PD	(*196*)
1512	Germany	Ground beetles	B	1994	2017	24	24	1		PD	(*197*)
1513	Italy	Freshwater Insects	A	1997	2013	17	6	6		PD	(*24*)
1515	Spain	Dung beetles	A	1983	2017	35	2	1		PD	(*198*)
1516	Sweden	Saproxylic beetles	A	2001	2013	13	1	3		PD	(*199*)
1517	China	Mosquitoes	A	1997	2009	13	6	13		PD	(*200*)
1518	USA: Ohio	Butterflies	A	1996	2016	21	60	21		private	(*201*)
1519	USA: New York & New Jersey	Mosquitoes	A	1932	2012	81	2	81		PD	(*18*)
1520	USA: Iowa	Mosquitoes	A	1969	2018	51	27	47	URL	CC-BY-NC	(*39*, *202*, *203*)
1521	Denmark	Springtails	A	1985	1999	15	2	8		PD	(*204*)
1524	Netherlands	Light-attracted insects	A	1997	2017	21	1	21		PD	(*205*)
1525	USA: Indiana	Mosquitoes	A	2008	2018	11	13	11		CC-BY	(*39*)
1526	USA: Florida	Mosquitoes	A	2007	2018	12	32	12		CC-BY	(*39*)
1527	USA: California	Mosquitoes	A	1954	2005	52	1	52		PD	(*18*)

Table S2. Posterior probabilities of the estimated mean trend being smaller than zero for all models in the main text.

In the main text, all estimates with a probability larger than 0.90 or smaller than 0.10 (two-tailed 80% credible interval) are treated as weak evidence, probabilities larger than 0.95 or smaller than 0.05 (two-tailed 90% credible interval) are treated as moderate evidence, and probabilities larger than 0.975 or smaller than 0.025 (two tailed 95% credible interval) as strong evidence. This is analogous to a two-tailed test of the IPCC(*206*) likelihood scales. Missing values indicate insufficient data. Probabilities showing weak, moderate, or strong evidence are denoted bold.

			Realm	
Figure	Estimate	Time period	Terrestrial	Freshwater
Fig 2a	combined realms	All years	0.681	
	Abundance + Biomass	All years	**0.994**	**0.009**
	Abundance	All years	**0.985**	**0.018**
	Biomass	All years	0.879	**0.075**
Fig 2b	Europe	All years	0.841	0.213
	North America	All years	**0.999**	**0.026**
	Latin America	All years	0.823	0.535
	Asia	All years	0.493	**0.066**
	Australia	All years	0.736	0.186
	Africa	All years	0.288	0.726
Fig 2c	Boreal / Alpine	All years	0.192	0.329
	Temperate	All years	**0.943**	**0.013**
	Drylands	All years	**0.998**	**0.006**
	Tropical	All years	0.617	0.793
Fig 3	Global	Since 1960	**0.996**	**0.011**
		Since 1970	**0.995**	**0.034**
		Since 1980	**0.992**	**0.030**
		Since 1990	**0.984**	**0.052**
		Since 2000	**0.909**	0.288
		Since 2005	0.764	**0.031**
	Europe	Since 1960	0.844	0.265
		Since 1970	0.846	0.480
		Since 1980	0.893	0.480
		Since 1990	0.846	0.295
		Since 2000	0.838	0.412
		Since 2005	0.865	0.087
	North America	Since 1960	**0.998**	**0.037**
		Since 1970	**0.998**	**0.069**
		Since 1980	**0.998**	**0.052**
		Since 1990	**0.994**	0.105
		Since 2000	**0.938**	0.401
		Since 2005	0.642	**0.090**

	Asia	Since 1960	0.490	**0.034**
		Since 1970	0.433	**0.033**
		Since 1980	0.440	**0.024**
		Since 1990	0.429	**0.038**
		Since 2000	0.198	
		Since 2005	0.240	
	Latin America	Since 1960	0.812	
		Since 1970	0.810	
		Since 1980	0.500	
		Since 1990	0.438	
		Since 2000	0.502	
		Since 2005	0.611	
	Australia	Since 1960	0.727	0.192
		Since 1970	0.623	0.252
		Since 1980	0.624	0.249
		Since 1990	0.548	0.337
		Since 2000		0.731
Fig. 4	Unprotected	All years	**0.998**	**0.006**
	Protected	All years	**0.965**	0.113

Table S3. Standard deviations of the different levels of random effects of the realm model.

	Random effect level	Standard deviation
Intercept	Study	1.138
	Study area	0.238
	Site	0.118
	Period in year	0.290
Slope	Study	0.0102
	Study area	0.0034
	Site	0.0025

Data S1. (separate file)

Data S1 and Data S2 are the dataframes used for all analyses and are intended to ensure reproducibility. Six datasets are not included because their access licenses preclude sharing of derived products: Datasource_ID's 1339, 1404, 1416, 1474, 1475. For access to the raw data follow the link in Table S1.

Column name	Explanation
Plot_ID	Unique identifier for each site. Always nested in a Datasource_ID
Datasource_ID	Unique identifier for each dataset. ID’s from BioTIME and GPDD were left as is.
Datasource_name	Name of Datasource_ID, for ease of recognition. Redundant with Datasource_ID.
Year	Year of sampling event
Period	Time of the year of sampling event (month / season)
Unit	Metric of assemblage size (factor: abundance or biomass)
Number	Abundance or biomass of insects observed at this sampling event
Realm	Realm of sampling: Terrestrial or Freshwater
Stratum	Stratum of capture: Air, tree layer, herb layer, soil surface, or underground.
biome	WWF ecoregion in which sampling took place
BiomeCoarse	Grouped WWF ecoregions into one of four climatic zones
Continent	Continent at which sampling took place
Region	Grouping of Countries or states into geographical units providing sufficient data for analysis
Country	Nation state in which sampling took place
Country_State	Country or state in which sampling took place (finer scale than Country)
Location	Unique identifier of study area or reserve of the sampling event. Not always nested in Dataset.
Duration	Duration of study
Start_year	First year in time series
End_year	Last year in time series
cYear	variable Year centered around mean for Inla analysis
iYear	Index year for random intercept
rYear	Copy of iYear for random slope
rYear2	Copy of iYear for random slope
Period_4INLA	Unique number for each Period for random intercept in Inla analysis
Plot_ID_4INLA	Unique number for each Plot_ID for random intercept in Inla analysis
Datasource_ID_4INLA	Unique number for each Datasource_ID for random intercept in Inla analysis
Location_4INLA	Unique number for each Location for random intercept in Inla analysis
Plot_ID_4INLAR	Unique number for each Plot_ID for random slope in Inla analysis
Datasource_ID_4INLAR	Unique number for each Datasource_ID for random slope in Inla analysis
Location_4INLAR	Unique number for each Location for random slope in Inla analysis

DSunit_4INLA	Unique number for each combination of Datasource and metric (abundance or biomass) for random intercept in DataS2
Locunit_4INLA	Unique number for each combination of Location and metric (abundance or biomass) for random intercept in DataS2
Plotunit_4INLA	Unique number for each combination of Plot_ID and metric (abundance or biomass) for random intercept in DataS2
DSunit_4INLAR	Unique number for each combination of Datasource and metric (abundance or biomass) for random slope in DataS2
Locunit_4INLAR	Unique number for each combination of Location and metric (abundance or biomass) for random slope in DataS2
Plotunit_4INLAR	Unique number for each combination of Plot_ID and metric (abundance or biomass) for random slope in DataS2
cStartYear	Centered start year for Inla analysis
cDuration	Centered duration for Inla analysis
cEndYear	Centered end year for Inla analysis
PA	Protection status. Binary: protected (yes) or not (no)
Start_forestArea	Percentage forest area at landscape scale surrounding the site at start of sampling from LUH2
End_forestArea	Percentage forest area at landscape scale surrounding the site at end of sampling from LUH2
Start_cropArea	Percentage cropland area at landscape scale surrounding the site at start of sampling from LUH2
End_cropArea	Percentage cropland area at landscape scale surrounding the site at end of sampling from LUH2
Start_pastureArea	Percentage pasture area at landscape scale surrounding the site at start of sampling from LUH2
End_pastureArea	Percentage pasture area at landscape scale surrounding the site at end of sampling from LUH2
Start_urbanArea	Percentage urban area at landscape scale surrounding the site at start of sampling from LUH2
End_urbanArea	Percentage urban area at landscape scale surrounding the site at end of sampling from LUH2
urbanization	Difference in % urban cover between start and end of time series at landscape scale
cropification	Difference in % cropland between start and end of time series at landscape scale
frcCrop900m1992	Fraction cropland at local scale surrounding the sampling site at the end of the sampling period (ESA CCI), only for datasets ending after 1991
frcUrban900m1992	Fraction urban cover at local scale surrounding the sampling site at the end of the sampling period (ESA CCI), only for datasets ending after 1991
mnC	Mean temperature (C) at sampling site over the sampling period at landscape scale around the site (CRU)
mnK	mean temperature (K) at sampling site over the sampling period at landscape scale (CRU)
deltaTmean	Change in mean temperature over the sampling period (K) at landscape scale (CRU)

relDeltaTmean	Change in mean temperature (K) / mean temperature at landscape scale (CRU)
mnP	Mean precipitation per month over the whole sampling period (mm) at landscape scale (CRU)
deltaPrec	Change in monthly precipitation over the sampling period (mm) at landscape scale (CRU)
relDeltaPrec	Change in monthly precipitation / mean precipitation (mm) at landscape scale (CRU)
CHELSAmnC	Mean temperature (C) at sampling site over the sampling period at local scale (CHELSA)
CHELSAmnK	Mean temperature (K) at sampling site over the sampling period at local scale (CHELSA)
CHELSAdeltaTmean	Change in mean temperature over the sampling period (K) at local scale (CHELSA)
CHELSArelDeltaTmean	Change in mean temperature over the sampling period (K) /mean temperature at local scale (CHELSA)
CHELSAmnP	Mean precipitation per month over the whole sampling period (mm) at local scale (CHELSA)
CHELSAdeltaPrec	Change in monthly precipitation over sampling period at local scale (mm)
CHELSArelDeltaPrec	Change in monthly precipitation over sampling period / mean monthly precipitation at local scale

Data S2: Dataframe for models estimating trend slopes of biomass and abundance (this includes abundance and biomass data from datasets that report both. In Data S1 only abundance data from these datasets are included. Column headers as above.

References and Notes

1. A. D. Chapman, *Numbers of Living Species in Australia and the World* (Toowoomba, ed. 2, 2009).

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