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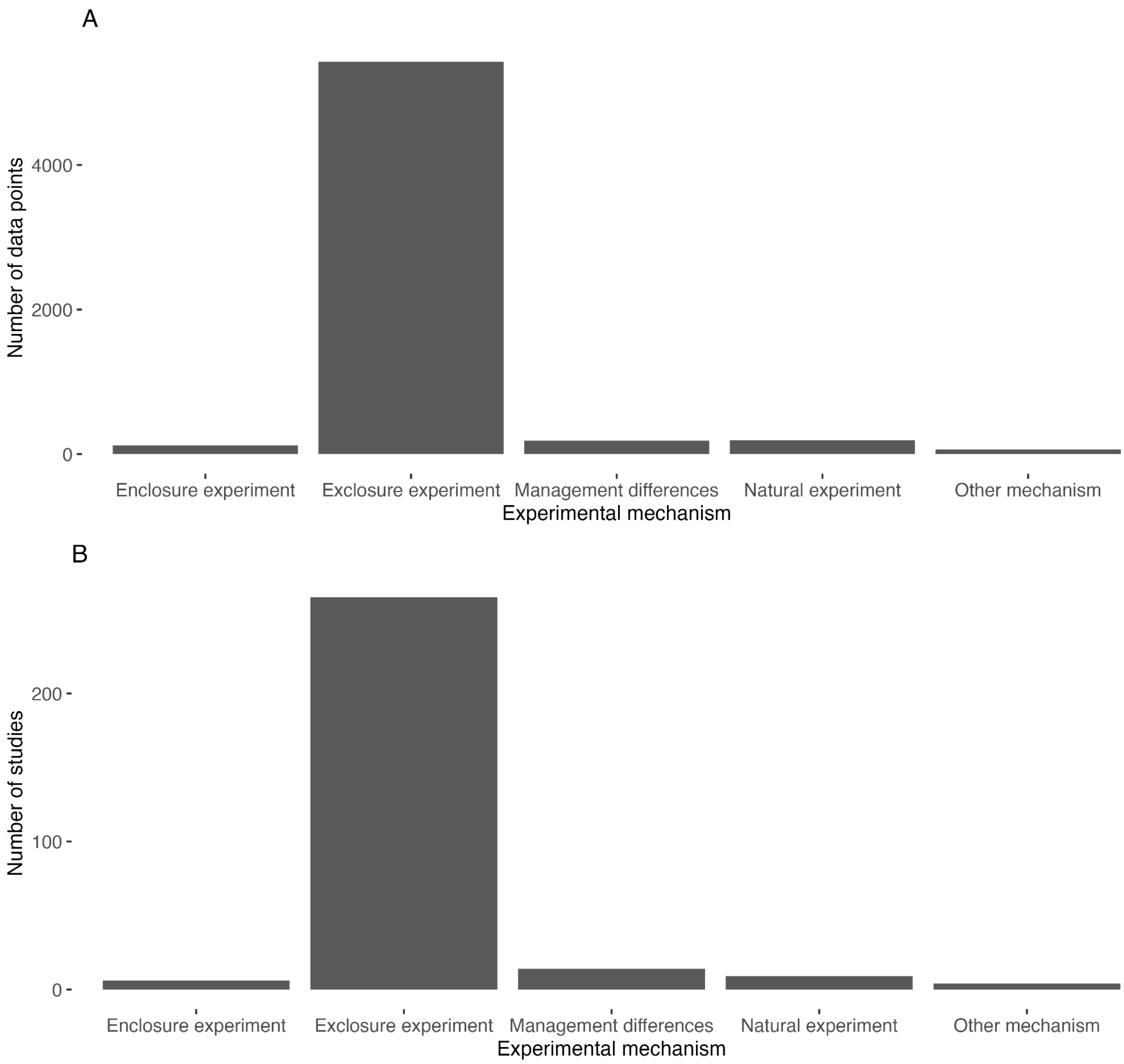

Fig. S1: Distribution of experimental mechanisms. A: Distribution of data points in experimental mechanisms; **B**: Distribution of studies in experimental mechanisms.

Table S1: Sample sizes of the different ecosystem responses

Ecosystem response	N studies	N data points
Litter cover	22	58
Soil labile P	11	30
Soil respiration	8	106
Soil total Ca	11	31
Soil total Mg	11	31
Soil decomposition rate	5	22
Soil total N	22	129
Soil total C	37	140
N mineralization rate	8	61
Soil total P	13	34
Soil labile N	14	88
Soil compaction	9	32
Bare ground	29	80
Plant biomass	106	1240
Plant C:N	7	25
Primary productivity	38	353
Plant cover	110	1140
Plant evenness	16	53
Plant alpha diversity	99	957
Plant total N	18	141
Small mammal abundance	18	194
Invertebrate alpha diversity	23	210
Bird abundance	13	121
Bird alpha diversity	10	60
Invertebrate abundance	47	632
Herpetofauna abundance	6	22
Total	297	5990

Table S2: Studies used for the meta-analysis.

Ecosystem response	Included studies
Litter cover	1–22
Soil labile P	8,23–32
Soil respiration	32–39
Soil total Ca	23,24,26–28,30,38,40–43
Soil total Mg	23,24,26–28,30,38,40–43
Soil decomposition rate	17,19,34,44,45
Soil total N	7,8,11,20,23–25,27–31,33,36,38,40–42,46–60
Soil total C	1,27,8,11,20,23,24,26–31,33,36,38–43,47–49,51,52,54–56,58,60–67
N mineralization rate	19,36,38,46,50,68–70
Soil total P	7,24,25,41–43,47,52,56,59,65,66,71
Soil labile N	23,24,32,41,46–48,50,52,58,64,69,72,73
Soil compaction	8,19,23,41,44,51,66,74,75
Bare ground	3,4,9,10,12,14,15,18,20,24,49,60,76–92
Plant biomass	5,9,10,12,13,21,28,30,33,35,36,40,42,46,47,51,54–57,59,60,66,68,70,73,80,83,84,86,88,92–165
Plant C:N	37,44,48,65,69,70,114
Primary productivity	12,20,24,26,34,37,51,55,61,69,73,90,101,112,115,122,124,125,140,150,159,166–182
Plant cover	3–6,8,12–15,17–20,24,29,30,39,41–43,49,56,59,60,65,67,71,73,76–78,80–82,84,85,87,88,90,91,101,102,107–110,124,127,132,133,135,136,140,143,148,149,152,158–160,162,166,175,183–229
Plant evenness	31,42,49,56,97,132,191,193,200,205,230–235
Plant alpha diversity	4–6,8,9,11,14,19,20,24,30,31,42,43,46,49,60,63,66,68,71,77,80,82,86,90,92,97,99,101,106–110,112,118,132–134,138,141,145,146,148–150,152,164,168,170,175,179,183,185,188,189,191–195,197–200,202,204–207,209,212–214,221,223,225,228,230–249
Plant total N	32,34,37,51,57,59,65,66,73,96,114,122,163,172,202,250–252
Small mammal abundance	19,24,123,153,188,253–265
Invertebrate alpha diversity	3,13,19,22,66,95,99,158,214,216,245,266–277
Bird abundance	1,44,47,78,85,98,102,143,196,278–281
Bird alpha diversity	77,78,85,102,143,196,279–282
Invertebrate abundance	1,3,13,17,22,28,39,43,47,66,84,88,95,99,120,135,163,164,182,202,214,216,217,222,245,260,266–272,274–277,281,283–291
Herpetofauna abundance	2,215,222,253,273,292

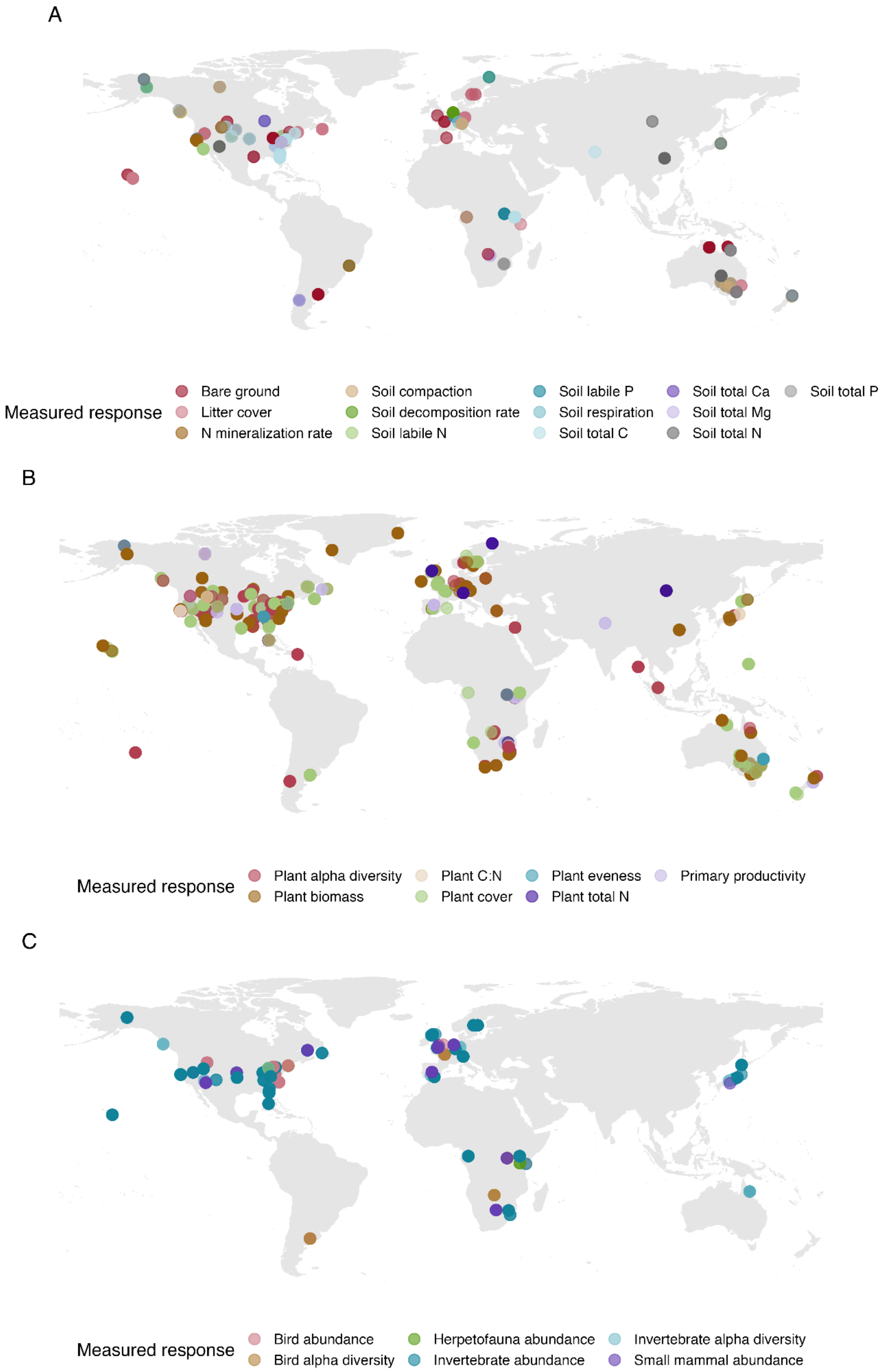

Fig. S2: Locations of the studies used in this meta-analysis. The different colors represent different measured responses. A: Locations of studies investigating soil responses; B: Locations of studies investigating vegetation responses; C: Locations of studies investigating responses of other animals.

Fig. S3: Locations of the studies used in this meta-analysis. The color indicates if the overall response of the specific nutrient in the respective study was positive or negative. This was calculated by taking the mean of the effect sizes (Hedges g) of all reported control/treatment combinations per study.

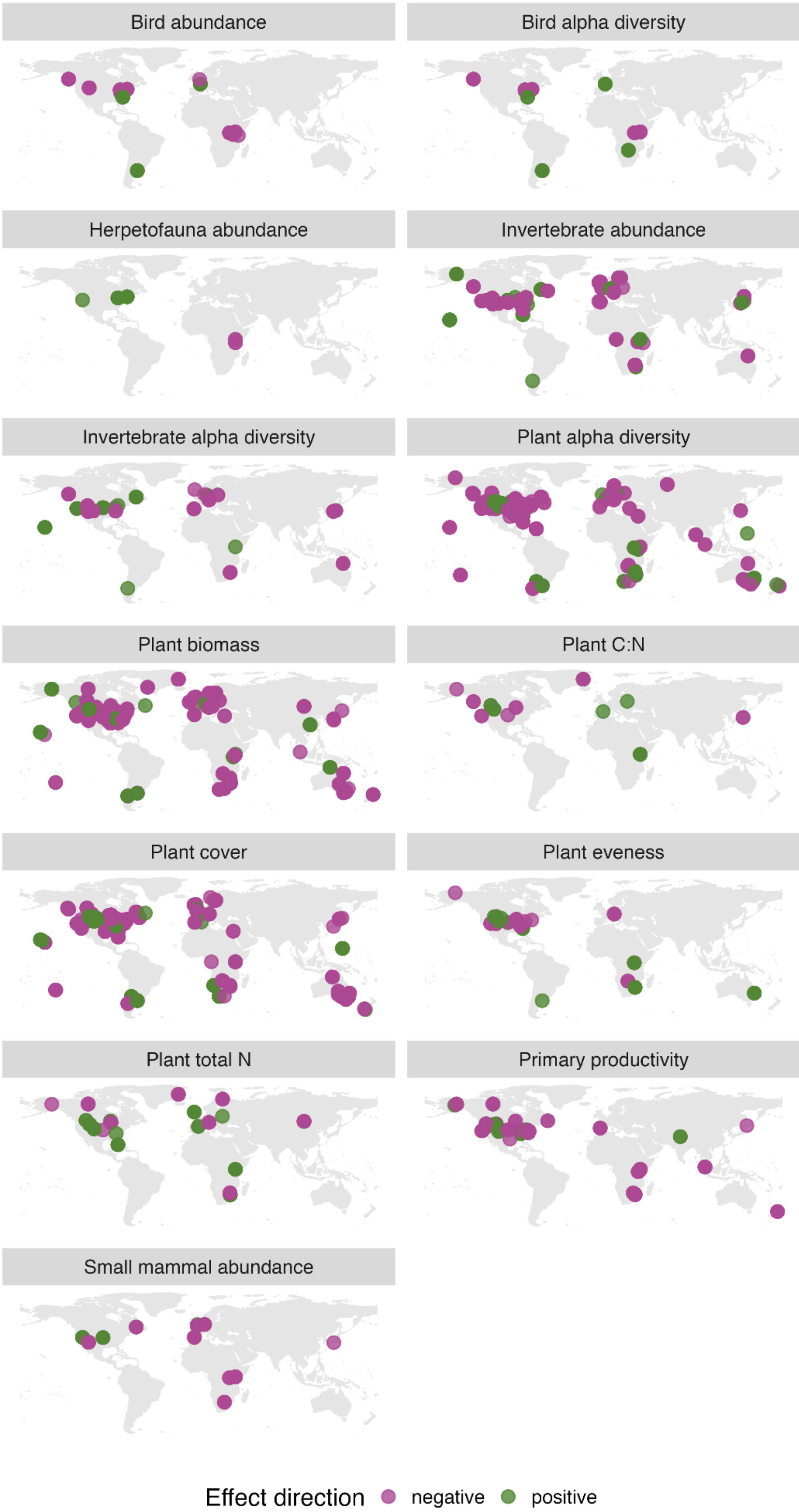

Fig. S3 continues.

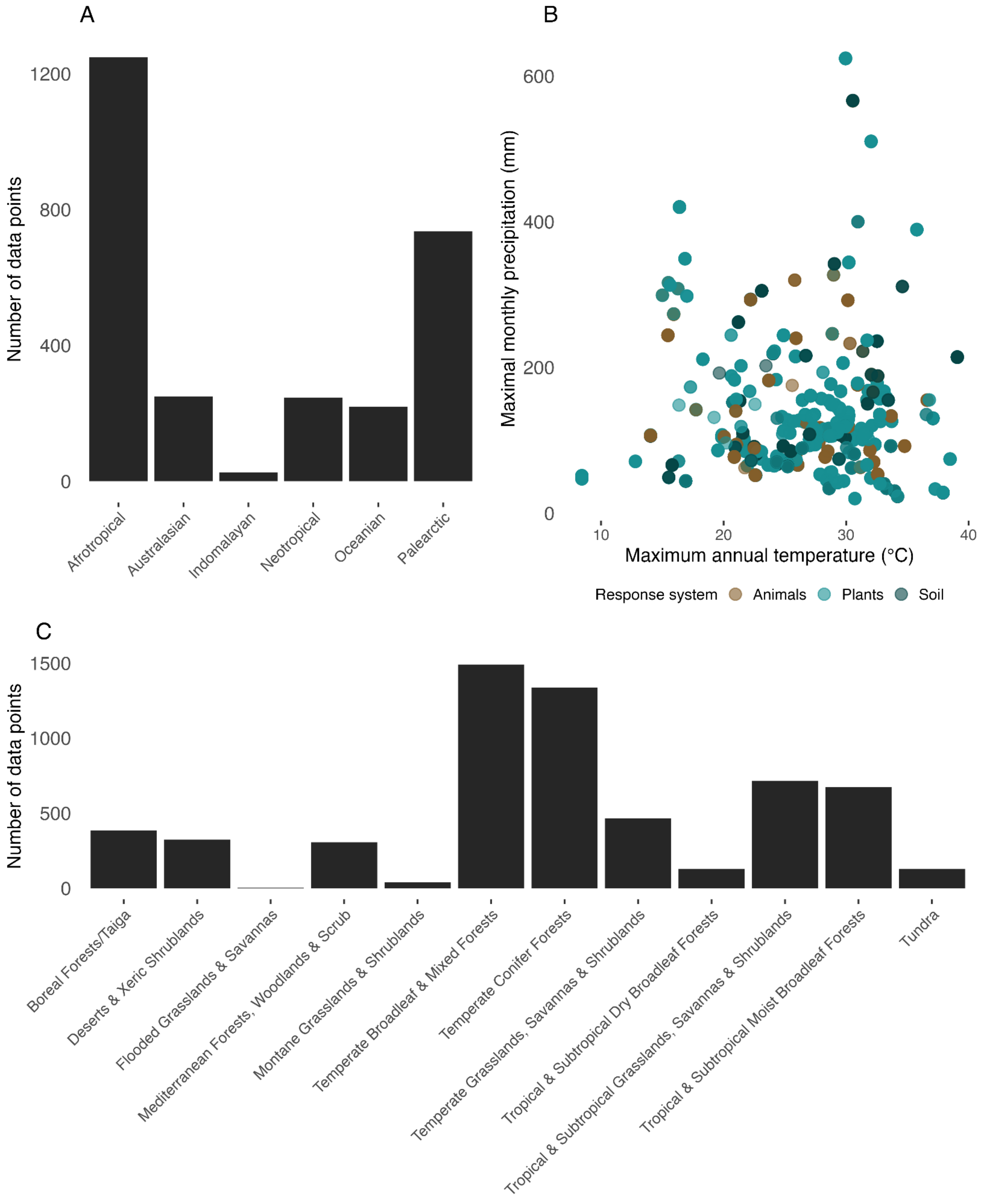

Fig. S4: Distribution of the data points used in the meta-analysis. A: Distribution of data points in biogeographical realms; B: Distribution of data points in temperature and precipitation; C: Distribution of data points in different biomes.

The geographic distribution of study sites shows a general lack of studies in South America, Africa (except for the southeast of the continent), and Asia (Fig. S2). Looking at each response-sphere combination separately, for example, reveals that there is not a single study investigating plant P and C concentrations in these continents (Fig S2).

The geographical bias towards North America, Europe and Australia is consistent with findings of other studies[293–295] (e.g., and can negatively impact model quality[293,296]). It is likely explained by the differing amount of available funding and resources for the different regions[296,297]. Especially considering the difference in effect direction between continents in our study (Fig. S3), for example only negative results for soil total P, C and labile N in Africa and Europe while Asia and North America showed also positive results, this bias is potentially seriously impacting our knowledge about general patterns.

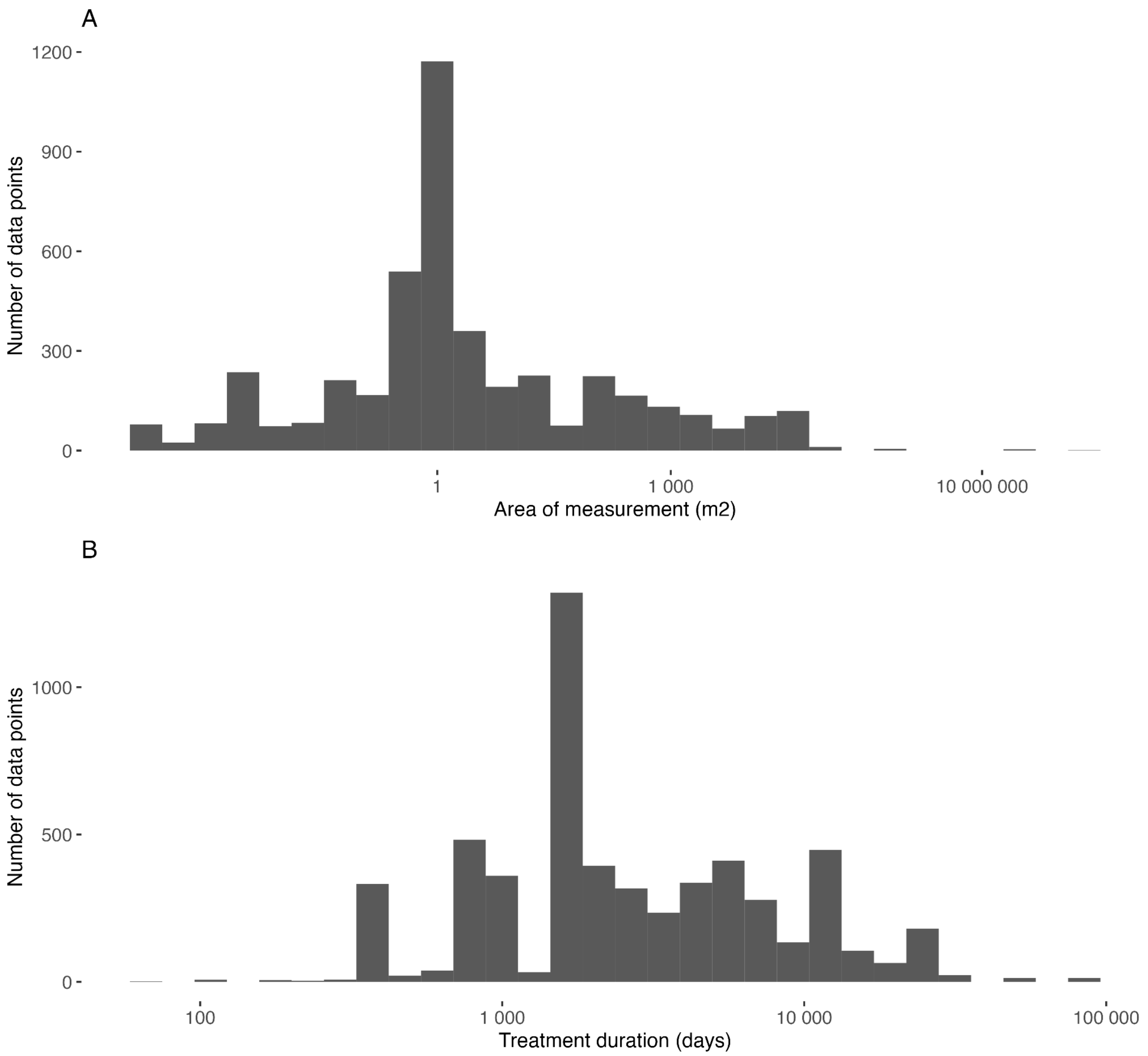

Fig S5: Distribution of plot size and treatment duration. A: Distribution of the size of the area of measurement. Area of measurement refers here to the area from which pairwise comparisons have been reported in the studies (i.e., plot size). Each reported pairwise comparison corresponds to one data point. Unfortunately, we don't have information about how far apart these plots were, as this was generally poorly described in the manuscripts. B: Time since treatment (e.g., exclosure establishment or island colonization).

Table S3: Combinations of tested covariates and responses. "All" refers to all responses with a sample size > 10 studies and > 20 data points, namely: bare ground, litter cover, soil total P, soil labile P, soil total C, soil total N, soil labile N, soil total Ca, soil total Mg, soil respiration, plant cover, plant biomass, plant diversity, plant evenness, primary productivity, plant N, invertebrate diversity, invertebrate abundance, bird abundance, small mammal abundance; * Here we tested only for absolute effect size magnitude.

Covariate	Response
Max species body mass	Soil labile P, soil total Mg, soil respiration, bird abundance
Community weighted max species body mass	Bare ground, litter cover, soil total C, soil total N, soil labile N, soil total P, soil total Ca, plant biomass, plant diversity, plant cover, plant evenness, primary productivity, plant N, small mammal abundance, invertebrate diversity, invertebrate abundance
Net primary productivity	All
Maximum annual temperature	All
Aridity index	All
Soil pH	All
Soil nitrogen	All
Soil clay content	All
Soil cation exchange capacity	All
Area of measurement	Bare ground, litter cover, soil total C, soil total N, soil labile N, plant evenness, plant diversity, plant cover, plant biomass, primary productivity, small mammal abundance, invertebrate abundance, invertebrate diversity; partly with reduced sample size.
Treatment duration	All; partly with reduced sample size
Biomass loss due to treatment*	Litter cover, soil total C, plant cover, plant biomass, plant diversity, small mammal abundance, invertebrate abundance; partly with reduced sample size

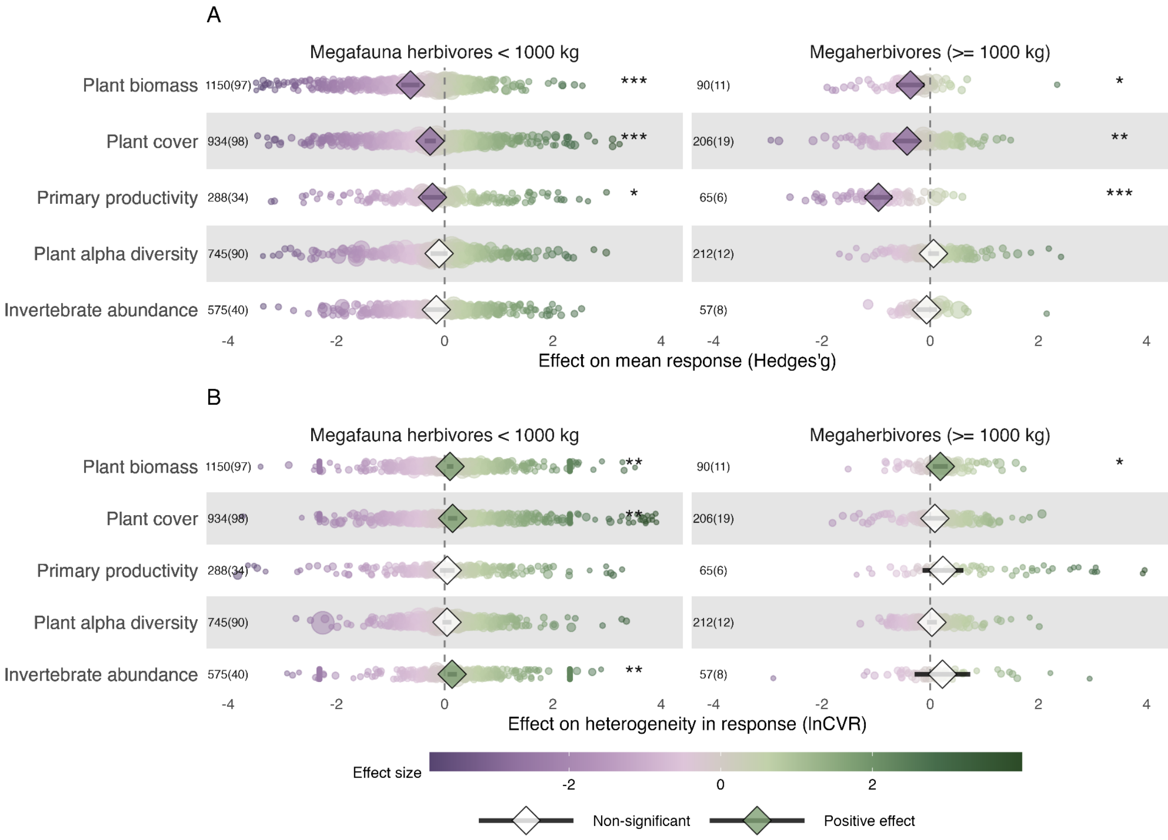

Fig. S6: Sensitivity analysis for megaherbivores. Model estimates (± 95% confidence intervals [CIs]) of intercept-only random-effects meta-analytic models for the different response parameters. Each point in the background refers to a data point used in the analysis of the respective response. Stars indicate different significance thresholds: *p≤0.05; **p≤0.01; ***p≤0.001. We note an overall similar trend between the two functional groups, with a more negative effect on the mean response of primary productivity and a more positive effect on plant alpha diversity by megaherbivores (> 1000 kg), such as indicated by the continuous body size variable in the main analysis. A: effect on mean response; B: effect on heterogeneity in response

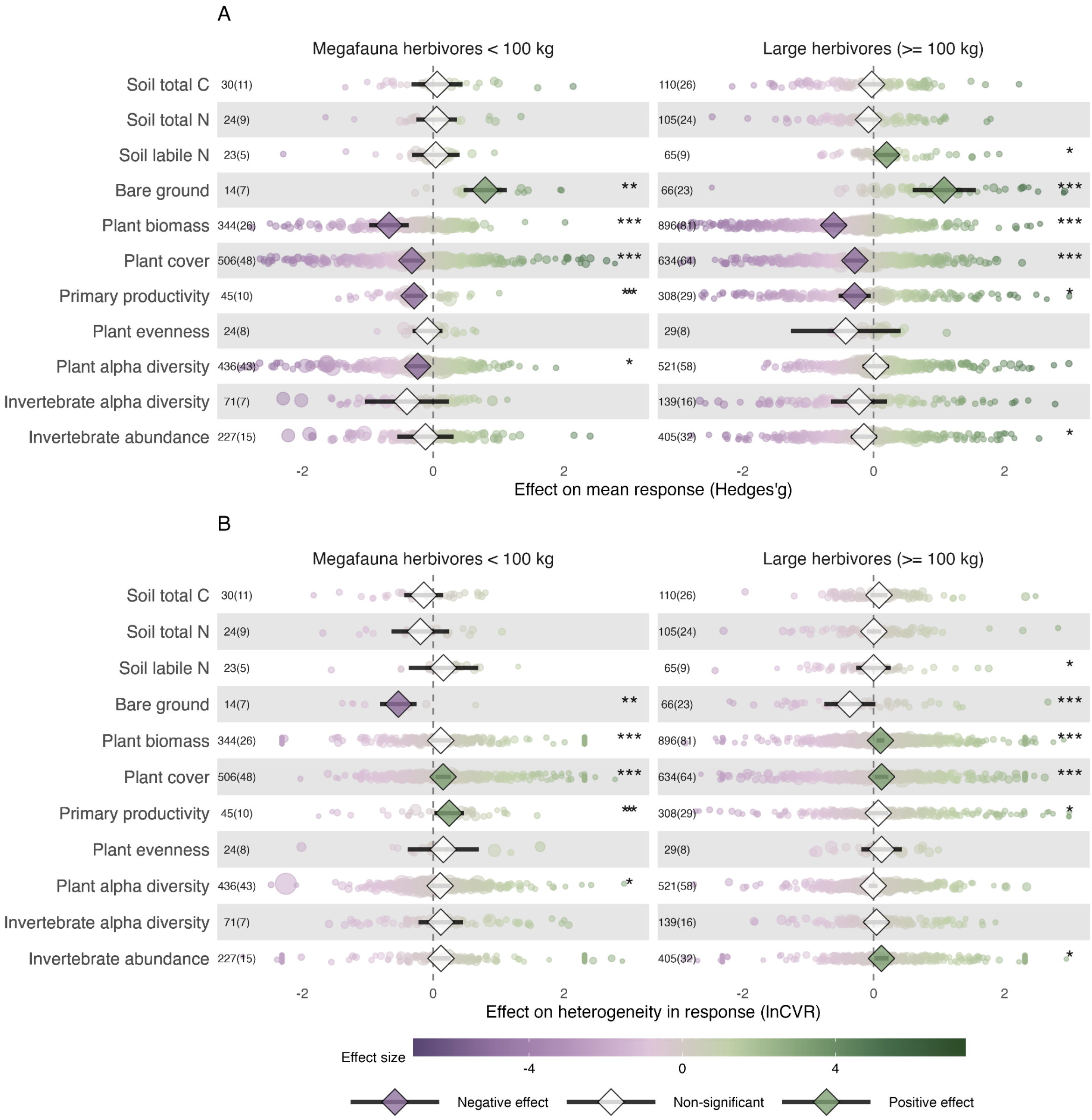

Fig. S7: Sensitivity analysis for large herbivores ≥ 100 kg. Model estimates (± 95% confidence intervals [CIs]) of random-effects meta-analytic intercept-only models for the different response parameters. Each point in the background refers to a data point used in the analysis of the respective response. Stars indicate different significance thresholds: *p≤0.05; **p≤0.01; ***p≤0.001. We note an overall similar trend between the two functional groups. However, large herbivores (>= 100 kg) have a significant positive impact on soil labile N, while megafauna herbivores < 100 kg have a significant negative impact on plant alpha diversity (such as indicated by the continuous body-mass covariate in the main analysis). A: effect on mean response; B: effect on heterogeneity in response

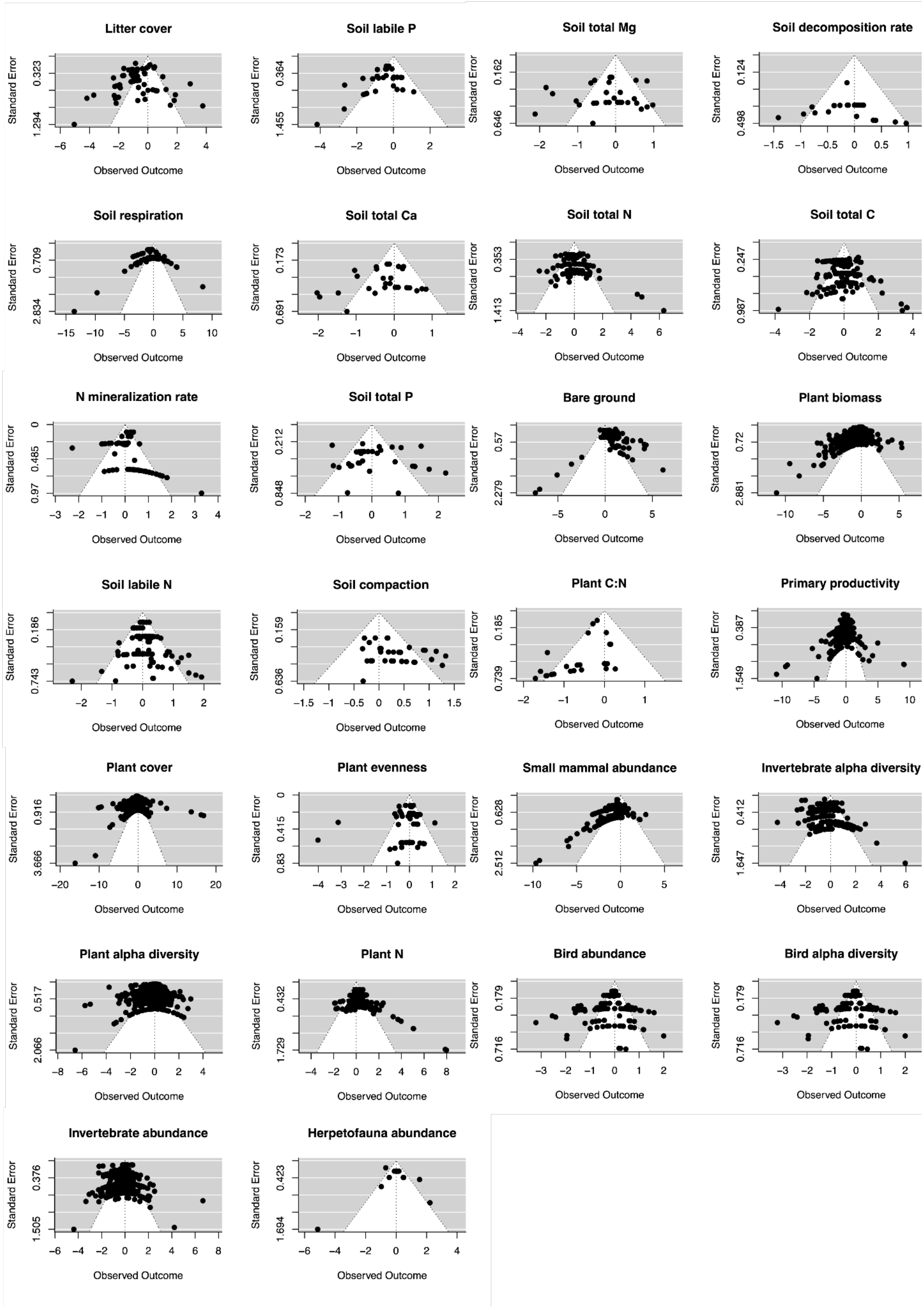

Fig. S8 Funnel plots of the different nutrient/sphere combinations. Dots outside the dashed lines can be an indication of publication bias [323].

The regression test for publication bias and the funnel plots showed a publication bias towards most responses (Table S4).

Table S4: Results of the regression test for funnel plot asymmetry[298]. Significance ($p \leq 0.05$) indicates potential publication bias[299].

* Indicates a significant test.

Ecosystem response	z	*p*
Litter cover	0.4878	0.6257
Soil labile P	-2.3798	0.0173*
Soil respiration	-1.8495	0.0644
Soil total Ca	-1.0327	0.3017
Soil total Mg	-0.2245	0.8224
Soil decomposition rate	0.5455	0.5854
Soil total N	2.7696	0.0056*
Soil total C	1.9048	0.0568
N mineralization rate	3.5236	0.0004*
Soil total P	0.5047	0.6138
Soil labile N	1.8051	0.0711
Soil compaction	1.9541	0.0507
Bare ground	-1.2777	0.2013
Plant biomass	-16.0007	< .0001*
Plant C:N	-3.0134	0.0026*
Primary productivity	-1.9095	0.0562
Plant cover	-4.9331	< .0001*
Plant evenness	-1.0560	0.2909
Plant diversity	-0.3882	0.6978
Plant total N	6.8278	< .0001*
Small mammal abundance	-9.8084	< .0001*
Invertebrate diversity	2.6335	0.0085*
Bird abundance	0.0639	0.9491
Bird diversity	0.9911	0.3216
Invertebrate abundance	0.6622	0.5078
Herpetofauna abundance	0.2153	0.8296

The presence of a bias towards significant positive or negative results is a common problem in ecology and science in general 324,325. Although some authors consider it to be an unavoidable byproduct of research (e.g., 325), we would argue that pressure to publish perpetuate these biases and compromise the integrity of scientific research 326,327. However, given the broad scope of this study paired with the use of random effect models, our results should nevertheless allow for reasonable generalizations. Additionally, asymmetry in the funnel plots may also be caused by high variability in the data (which is present here) 328 .

The presence of a bias towards significant positive or negative results is a common problem in ecology and science in general[300,301]. Although some authors consider it to be an unavoidable byproduct of research[300], we would argue that pressure to publish perpetuate these biases and compromise the integrity of scientific research[302,303]. However, given the broad scope of this study paired with the use of random effect models, our results should nevertheless allow for reasonable generalizations. Additionally, asymmetry in the funnel plots may also be caused by high variability in the data (which is present here)[304].

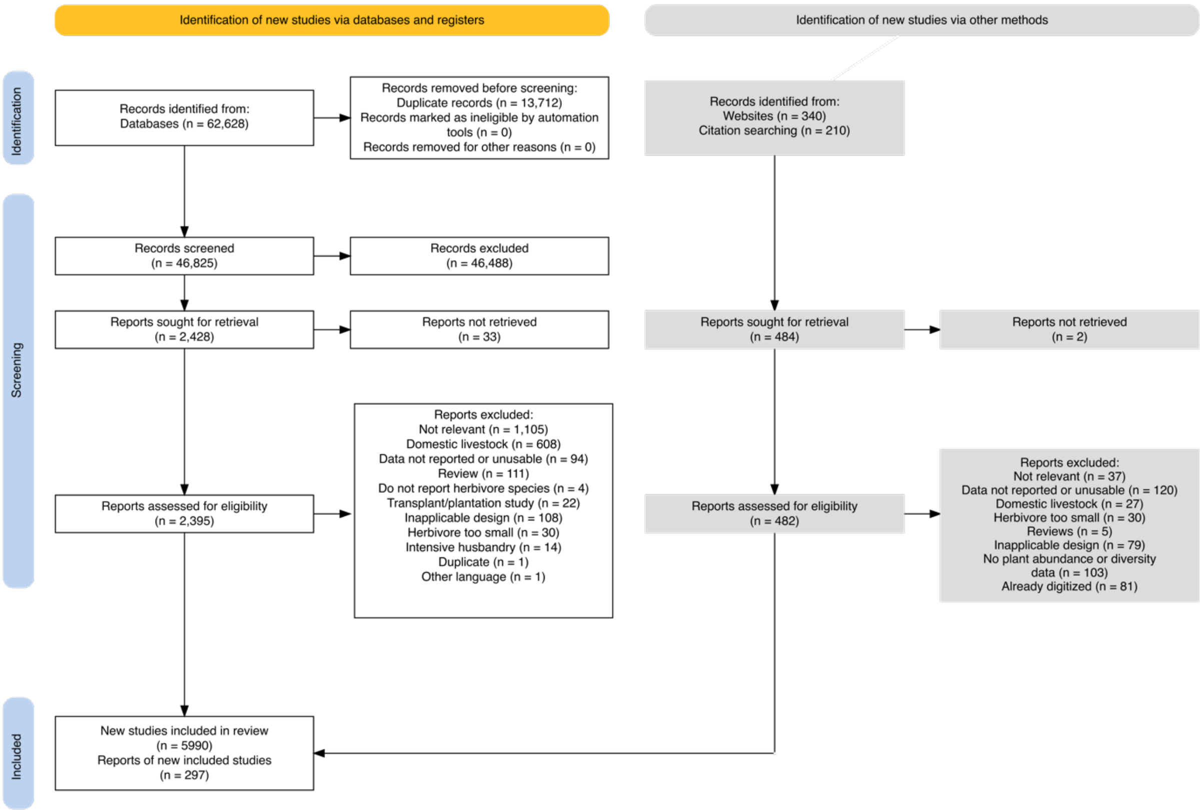

Fig. S9 Prisma flow diagram. Here we summarized the literature search process according to the PRISMA guidelines[305]. While most numbers are accurate, some are rather estimates based on the memory of the investigating team. Note also the difference in terminology. While we use studies for published articles,in the PRISMA terminology a study corresponds to a data point and a report is a published article.

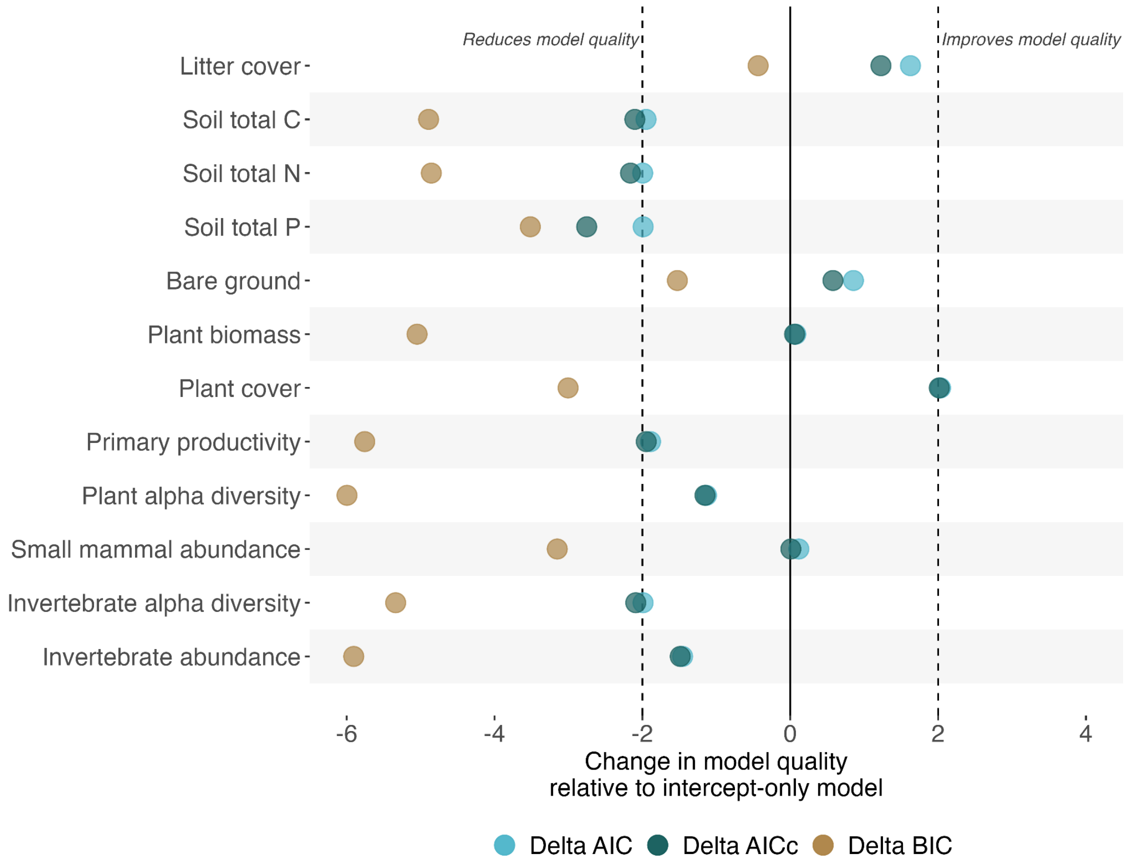

Fig. S10 Impact of megafauna nativeness. Comparison between intercept-only models and models with megafauna nativeness as variable. A delta BIC, delta AIC or delta AICc ≤ 2 indicates that there is no significant difference between the models[306]. Hence, adding nativeness almost never improved model quality, but often significantly reduced model quality. But note that delta AIC for plant cover = 2.03 and delta AICc = 2.01. The estimates for the impact of both introduced and native megafauna on plant cover, however, are negative. All models, except of plant cover (p = 0.44), had a likelihood ratio test (one sided) p value > 0.05.

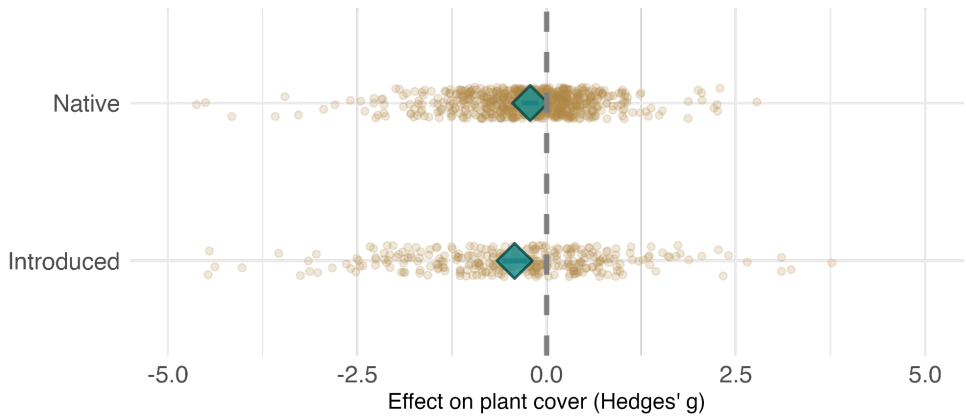

Fig. S11: Impact of native and introduced megafauna on plant cover. Although adding herbivore nativeness significantly improved model fit for plant cover, we note that the estimates for both introduced and native megafauna are negative.

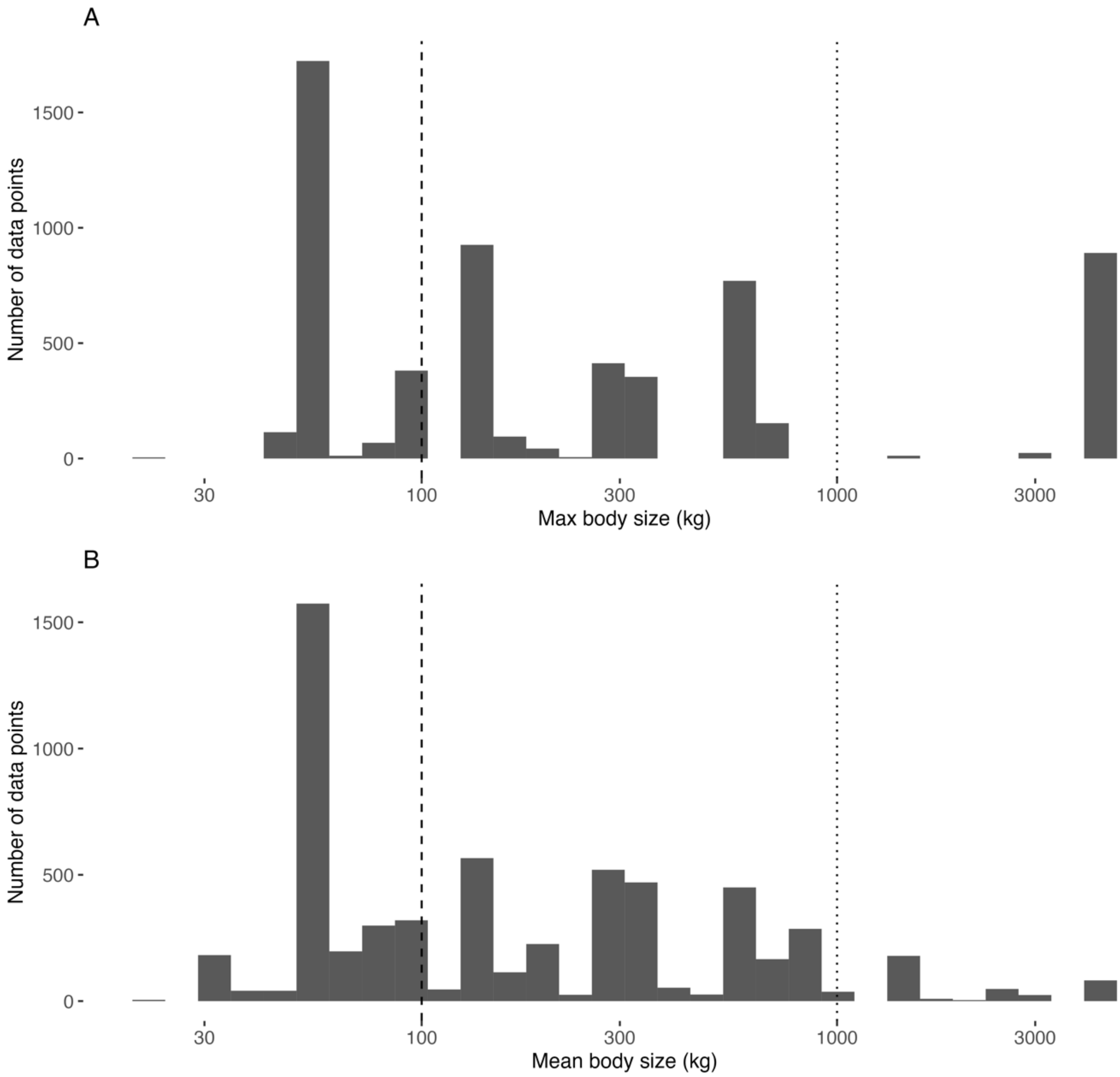

Fig. S12: Distribution of body size. The vertical lines mark the size cut-offs we used of our body size sensitivity analysis (dotted = 1000 kg, dashed = 100 kg; Fig S6 & S7). **A**: Distribution of maximal body size (the largest animal in the study); **B**: Distribution of mean body size (average of all occurring herbivores, incl. herbivores < 45 kg that were part of the experimental manipulation).

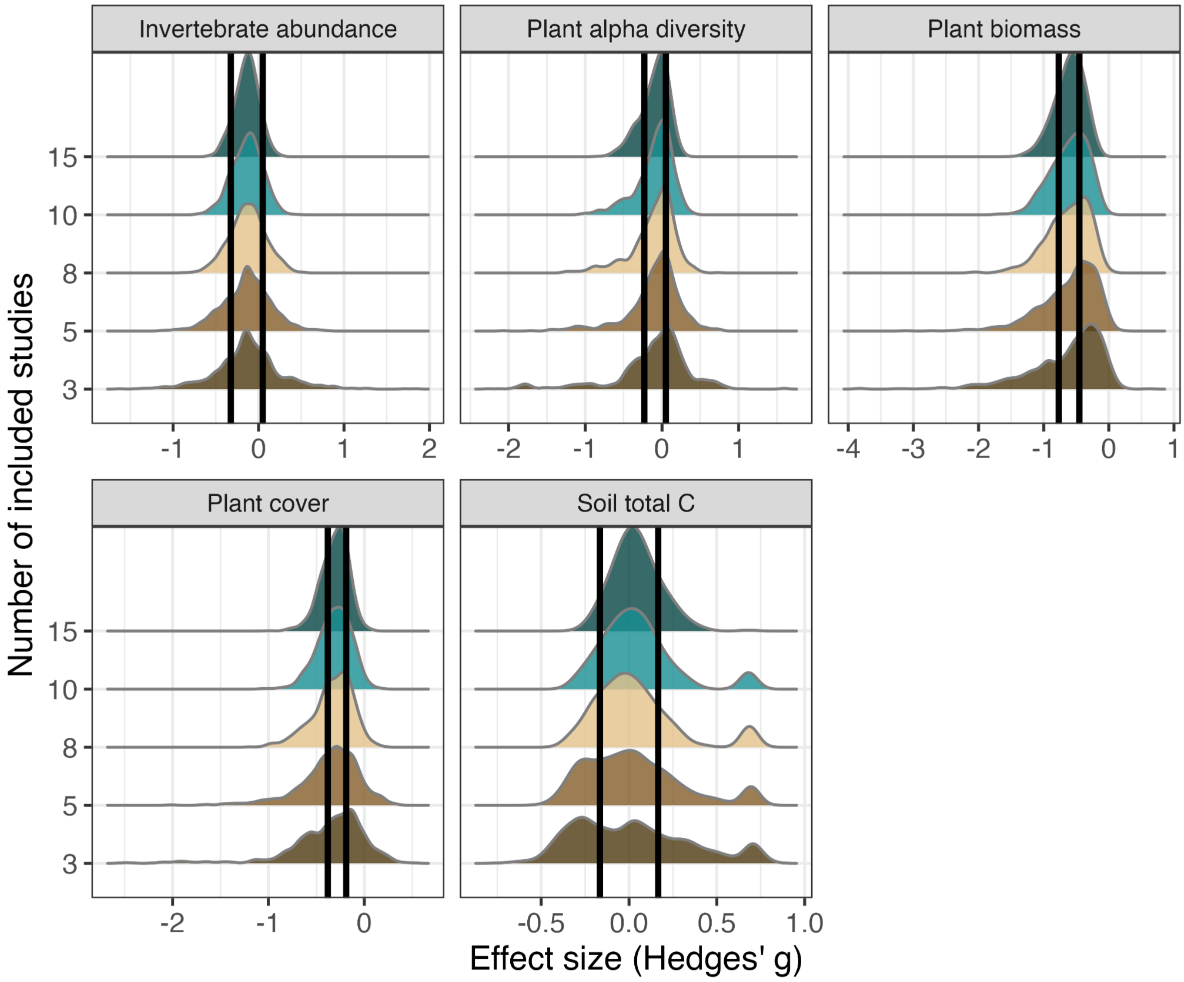

Fig. S13: Sample size sensitivity analysis. This figure shows the estimate frequency distribution of the five responses with the largest sample sizes. The black vertical lines mark the upper and lower border of the 95 % confidence interval of the models with full sample size.

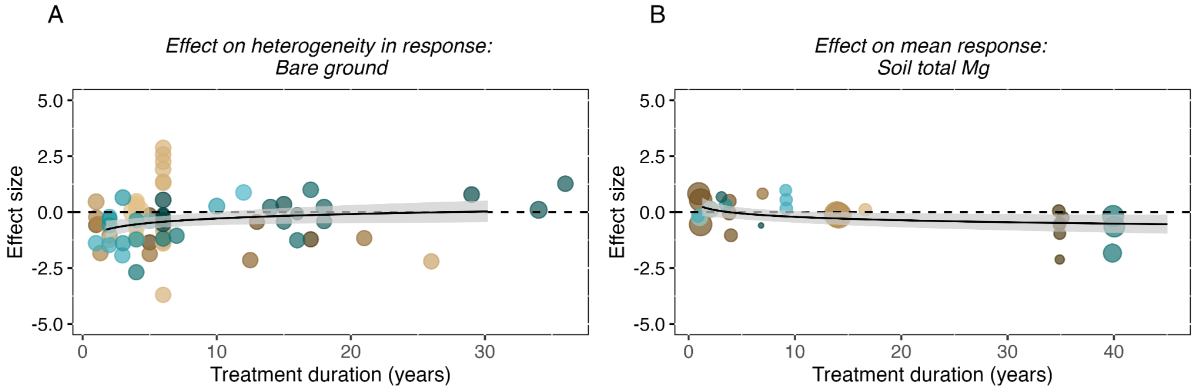

Fig. S14: Estimates (± confidence intervals) of responses significantly influenced by treatment duration. Different colors of the points indicate different studies. We note that the effect on the heterogeneity in bare ground cover **(A)** tends to get less negative over time while the effect on soil Mg **(B)** shows a negative trend over time**.**

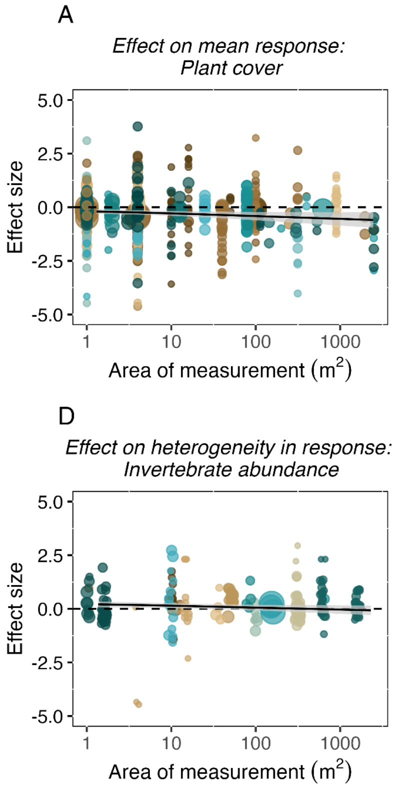

Fig. S15: Estimates (± confidence intervals) of responses significantly influenced by the area of measurement. Different colors of the points indicate different studies. We note overall small effect sizes. **A:** The effect on plant cover is more negative at larger scales; the effect on heterogeneity in plant cover **(B)** and primary productivity **(C)** gets more positive with increasing plot size**; D:** the effect on heterogeneity in invertebrate abundance shows a weak but significant negative relationship with area of measurement.

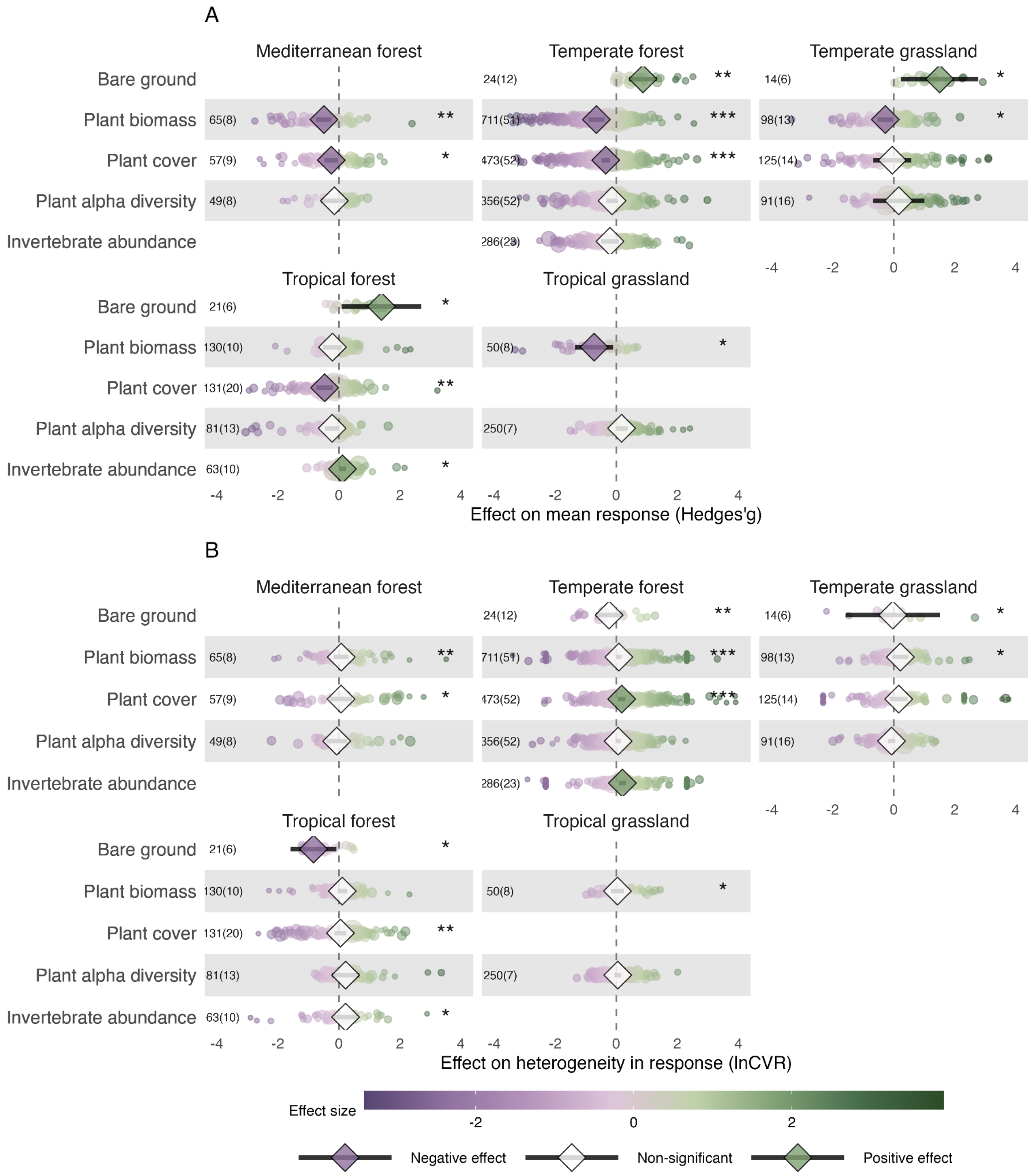

Fig. S16: megafauna effect in different biomes. Shown are model estimates (± 95 % confidence interval) from intercept-only random-effects meta-analytic models. The points in the background refer to the included data points**. A**: Impact on mean response; **B**: impact on heterogeneity in response. While we observe an overall similar trend of megafauna impacts in different biomes, we note a non-significant positive impact on plant alpha diversity in grassland biomes and an non-significant negative impact on plant alpha diversity in forest biomes. This difference in impact is likely not (exclusively) explained by differences in megafauna body size between the biomes (Fig. S18) in line with previous synthesis who concluded that - if any - a positive effect of large herbivores on plant diversity occurs mainly in grasslands[307]. Moreover, we note a significant positive impact on invertebrate abundance in tropical forests.

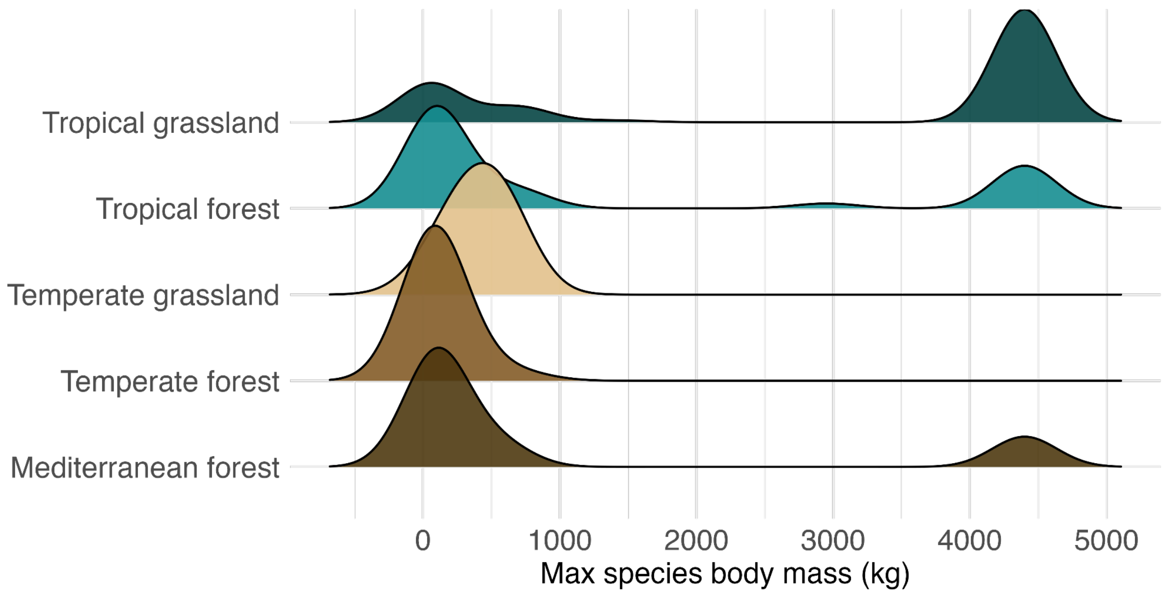

Fig. S17: Body size distribution in the different biome-categories.

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