Direction of plant-soil feedback determines plant responses to drought

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Supporting Information

Supplementary Figures

Appendix One

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Appendix Three

Appendix Four

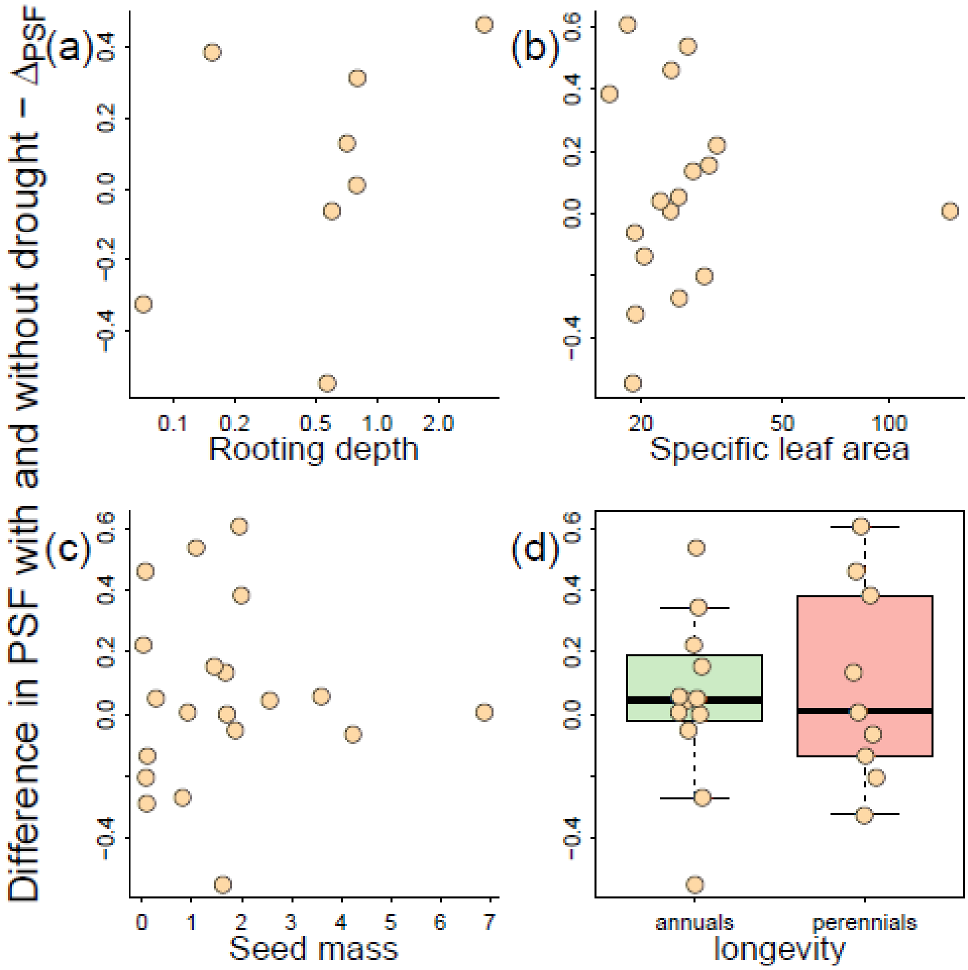

Fig. S1, Relationships between Δ_{PSF} and (a) rooting depth; (b) specific leaf area; (c) seed mass and (d) longevity. We present dedicated statistics in Appendix One.

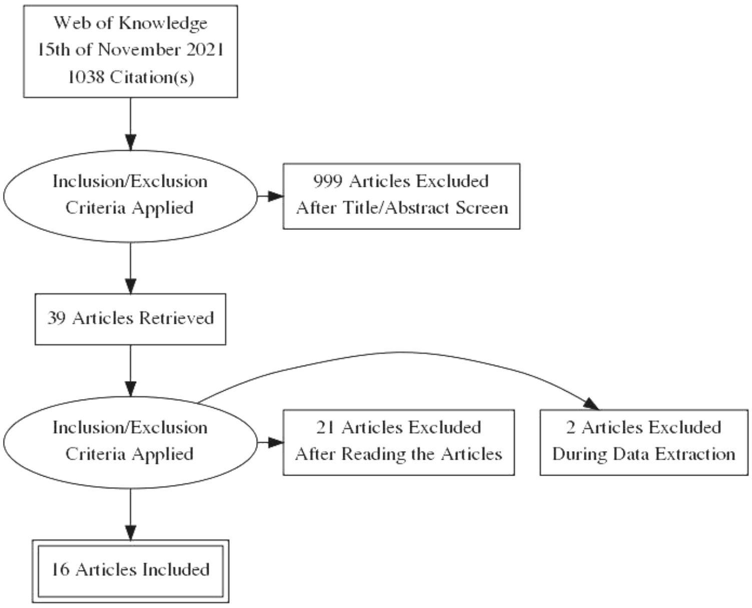

Fig. S2. PRISMA flow diagram for the meta-analysis we describe in the article. We used the following search string: "drought AND (soil feedback* OR PSF)". We further list the raw data in Appendix Three.

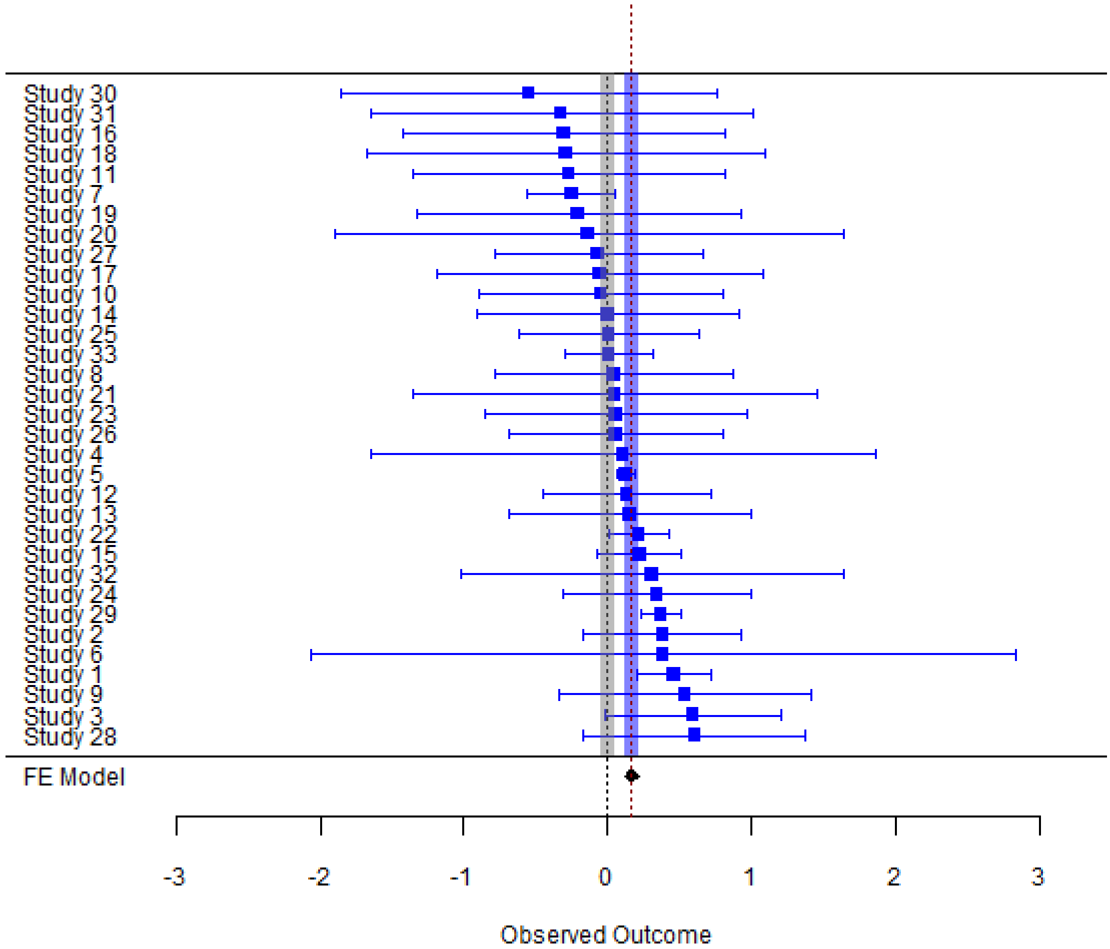

Fig. S3. Forest plot depicting the effect sizes across studies as we used them to assess statistical power. Each effect is depicted as a rectangle (mean) and its 95% confidence intervals (CIs). The black discontinuous vertical line is the no-effect line and the grey shaded line around it the area where effects are not-significant. We highlight with a red discontinuous line the mean effect in our meta-analysis and we shaded the area of no-effect around it in blue. The statistical power of a study with 10 replicates is 0.18, The M error statistic, describing the proportion by which the critical value must exceed the effect size to make it significant, for any study consisting of 10 replicates is 1.48. The observed S error statistic describing the probability that a significant statistic has the opposite sign that the one observed is 35%.

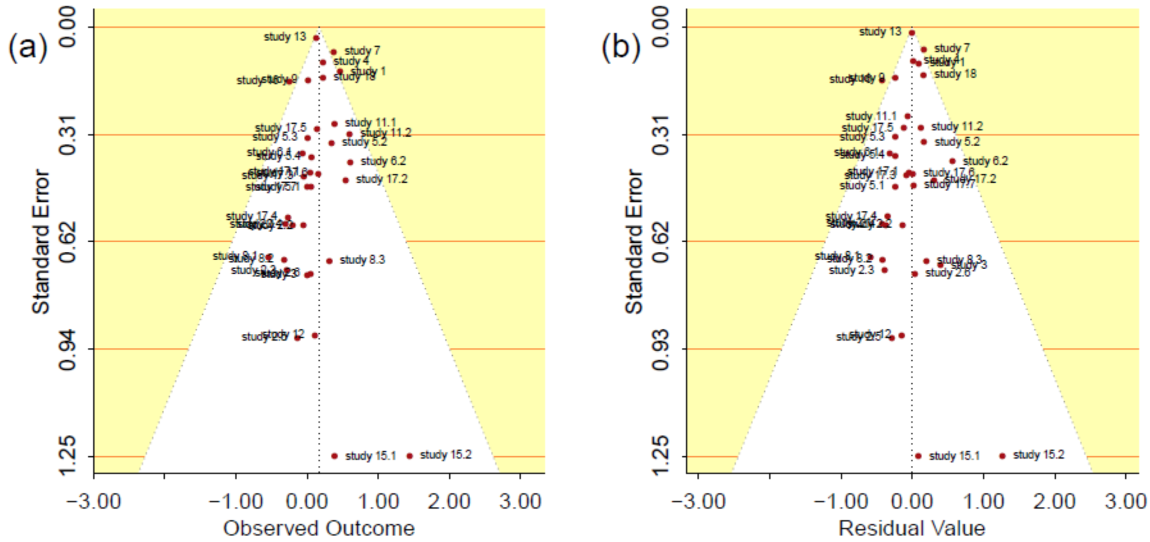

Fig. S4 Funnel plots for (a) the model with Δ_{PSF} as response and no predictors and (b) the model with average PSF as a predictor. We observed no evidence for a publication bias.

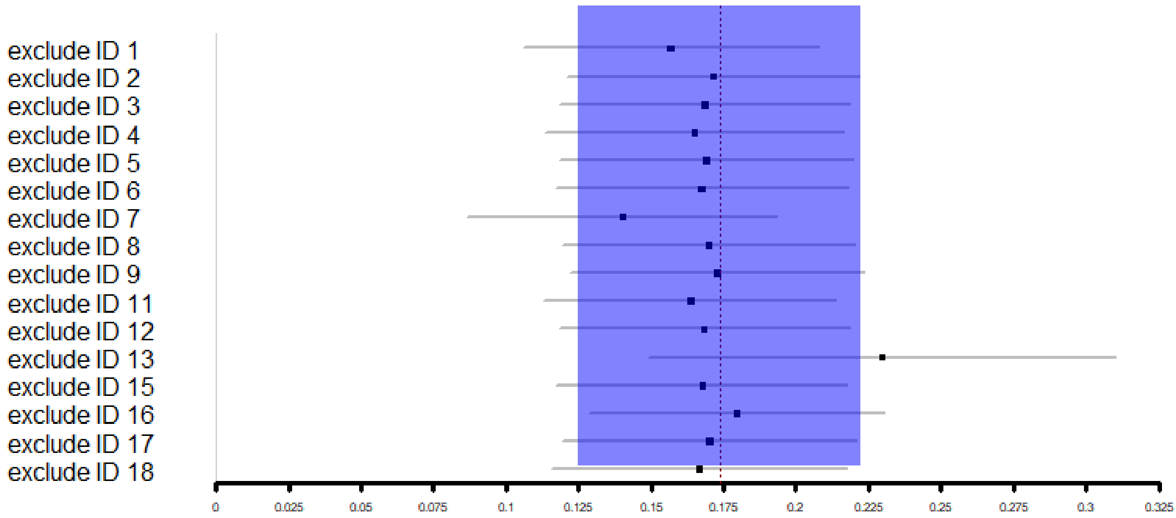

Fig. S5. Remove-one sensitivity analysis. The response variable was Δ_{PSF} and on the left we report on the ID of the studies we excluded. The mean Δ_{PSF} after exclusion is presented as a black rectangle and the 95% CIs as grey lines. We overlay in the form of a red line the effect size with all studies together and the 95% CIs in the form of a blue shaded area.

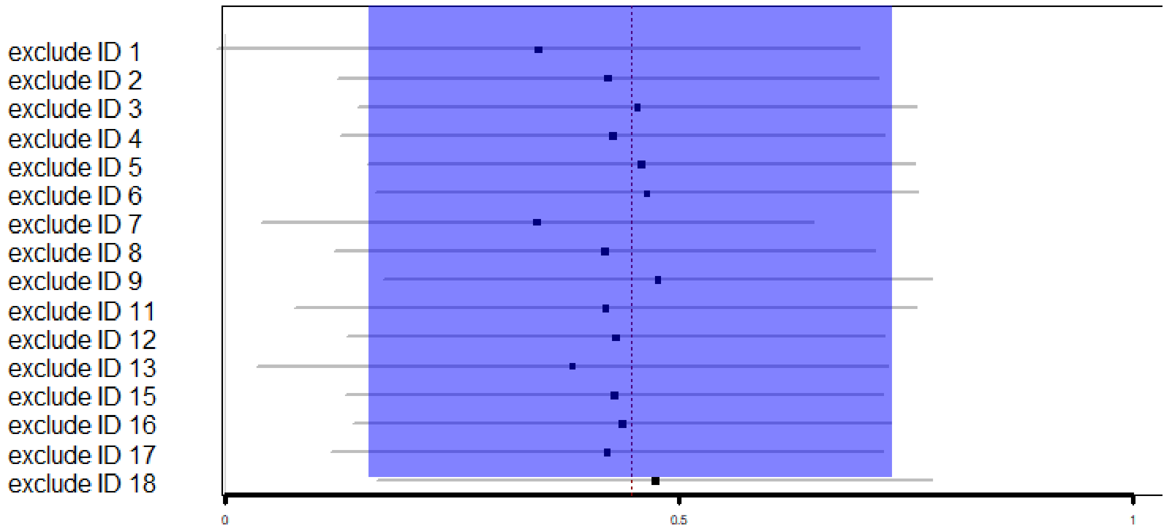

Fig. S6 Remove-one sensitivity analysis. The response variable was the meta-regression coefficient for average PSF and on the left we report on the ID of the studies we excluded. The mean Δ_{PSF} after exclusion is presented as a black rectangle and the 95% CIs as grey lines. We overlay in the form of a red line the effect size with all studies together and the 95% CIs in the form of a blue shaded area.

Appendix One: The meta-analysis

1 Detailed Materials and Methods

1.1 Sources of Data

On the 15th of November 2021 we searched Web of Knowledge with the search string "drought AND (soil feedback* OR PSF)". The search yielded 1038 hits. We screened those 1038 studies in relation to the fit of their title and abstract and narrowed our focus to 39 eligible studies. Our five inclusion criteria were as follows:

(1) The study (feedback stage) described an experimental drought but also contained control experimental units receiving more water than plants in the drought treatment. In the one case that there were more than two levels of watering availability we took the two extreme ones

(2) It was possible to determine the plant species that had been used in the study

(3) The plant species had been grown in trained by the same plant species soil but also in sterilized soil which we used to calculate the PSF index

(4) The authors reported on either aboveground biomass (which we preferentially used for compatibility with the existing literature), total biomass, or seed biomass and it was possible to calculate the log response ratio of those reported statistics in trained vs sterilized soil

(5) It was possible to extract or estimate the standard deviation of the PSFs following drought and in the control as well as assess the number of replicates in each of these two treatments. In one case were PSF data were presented as a boxplot we used as a mean PSF the median (i.e. a good proxy if values are normally distributed) and calculated the standard deviation as 1/1.349 times the interquartile range (also a proxy that assumes a normal distribution of the values).

We manually processed the remaining 39 studies (and 71 trials) through reading the body of the manuscripts to arrive to the final number of sixteen eligible studies. In the cases when we had to digitize plots to extract data, we did so with Plot Digitizer v2.6.8. The number of studies we included in our meta-analysis is considerably larger than the seven studies on drought that were included in Beals et al. 2020.

1.2 Transformations and effect sizes

The log response ratio of biomass of plants growing in trained soil over plants growing in sterilized soil is often termed a PSF index. Our effect size (Δ_{PSF}) was the difference in the PSF index of plants growing under drought conditions over those growing under control conditions:

$$\Delta_{PSF} = \ln \frac{\overline{m}_{d,t}}{\overline{m}_{d,s}} - \ln \frac{\overline{m}_{c,t}}{\overline{m}_{c,s}} \qquad \ldots(1)$$

with *m* we describe biomass estimates (usually aboveground biomasses but in some cases total biomass or seed biomass) and the indices *d*, *c*, t, *s* standing for drought, control, trained soil, sterilized soil, respectively.

We estimated the standard deviation for each PSF index from variance estimates on biomasses in the case that this had not been done in the study as follows:

$$\sigma_{PSF} = \left(\frac{\sigma_{m(s)}{}^{2}}{n_s \left(\overline{m}_s\right)^2} + \frac{\sigma_{m(t)}{}^{2}}{n_t \left(\overline{m}_t\right)^2} \right)^{1/2} \qquad \ldots(2)$$

with *n* here describing sample sizes and the indices as in (1).

The variance of the summary or the subtraction of two variables X, Y can be calculated as:

$$\sigma_{(X \pm Y)}{}^{2} = \sigma_{(X)}{}^{2} + \sigma_{(Y)}{}^{2} \pm 2\,\mathrm{cov}(X, Y) \qquad \ldots(3)$$

In our analysis we abstracted the two PSF indices as independent to each other and calculated the variance of Δ_{PSF} as follows:

$$\sigma_{\Delta_{PSF}}{}^{2} = \sigma_{(PSF_C)}{}^{2} + \sigma_{(PSF_D)}{}^{2} \qquad \ldots(3)$$

through assuming that the covariance term was zero, we increased the variance of Δ_{PSF} and reduced the weight of our observations, making our analysis more conservative.

Study weights were calculated as the inverse of variance: $1/(\sigma\,(\Delta_{\mathrm{PSF}}))^2$.

1.3 Meta-analysis

A major consideration in ecological meta-analyses, which is often violated, is addressing issues were studies report multiple contrasts (often termed trials; Gurevitch and Hedges 1999). To address such dependencies we combined trials originating from the same study and describing PSF index responses of the same plant species through carrying out a fixed-effects meta-analysis (as proposed in Lajeunesse 2011). We pooled studies at the stage of summarizing PSF indices and then used the pooled estimates per study per plant to assess Δ_{PSF}. We considered in our meta-analysis, as a result, trials originating from the same study but describing a different plant species independent. We rationalize this in terms of the sharp differences in growth conditions (i.e. plant species differ considerably in relation to their adaptations to any given conditions) which different plants pose but also of the resulting PSF index values that plant-soil feedbacks targeting different plants can comprise.

We assessed the degree to which our observations conformed with the assumptions of normality visually and report on heterogeneity statistics in all instances when we present results from the tests. Because the $Q_{heterogeneity}$ statistic of the meta-analysis was non-significant we used a fixed-effects methods of moments for our meta-analysis. To assess publication bias we used funnel plots. The analysis was carried out in R version 3.6.1 with the help of the library metafor (Viechtbauer 2010).

1.4 Sensitivity Analysis

We implemented a remove-one sensitivity analysis to identify influential studies in the dataset For the remove-one sensitivity analysis we repeated the meta-analysis iteratively through excluding one study at a time and assessed effect sizes and significance of the effects in the absence of the given study. For a study to be considered influential (and thus to be driving the results which is undesirable) the mean effects without the study should be outside the confidence intervals that have been estimated with all other studies in the dataset.

1.5. Relationships with traits

We extracted trait information from the LEDA database (Specific Leaf Area, Seed Mass and Plant Longevity: Kleyer et al. 2008) and the GRootT database (Rooting depth: Guerrero-Ramirez et al. 2021). In the cases when there were more than one values per species we used the median. Analyses were carried out with non parametric spearman correlation tests between the median trait values and Δ_{PSF}.

2. Detailed results

Full model without moderators. Response variable is ΔPSF and this is a fixed effects models based on the method of moments.

```
Random-Effects Model (k = 35; tau^2 estimator: DL)

tau^2 (estimated amount of total heterogeneity): 0 (SE = 0.0089)
tau (square root of estimated tau^2 value):      0
I^2 (total heterogeneity / total variability):   0.00%
H^2 (total variability / sampling variability):  1.00
```

```
Test for Heterogeneity:
Q(df = 34) = 33.8291, p-val = 0.4760

Model Results:

estimate      se    zval    pval   ci.lb   ci.ub
  0.1683  0.0255  6.5930  <.0001  0.1182  0.2183  ***

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The actual model with mean PSF index as predictor (under drought and control conditions) was as follows (again we used a fixed effects model using the method of moments):

```
Fixed-Effects with Moderators Model (k = 35)

I^2 (residual heterogeneity / unaccounted variability): 0.00%
H^2 (unaccounted variability / sampling variability):   0.78

Test for Residual Heterogeneity:
QE(df = 33) = 25.7619, p-val = 0.8112

Test of Moderators (coefficient 2):
QM(df = 1) = 8.0672, p-val = 0.0045

Model Results:

         estimate      se    zval    pval   ci.lb   ci.ub
intrcpt    0.2124  0.0299  7.1088  <.0001  0.1538  0.2709  ***
mods       0.4296  0.1512  2.8403  0.0045  0.1331  0.7260   **

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

To assess the relationship between Δ_{PSF} and rooting depth we used the following model:

```
> cor.test(log(dataES$rdepth), dataES$ESmain)

        Pearson's product-moment correlation

data:  log(dataES$rdepth) and dataES$ESmain
t = 1.084, df = 6, p-value = 0.32
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.4196702  0.8631970
sample estimates:
      cor
0.4046783
```

```
> cor.test(dataES$rdepth, dataES$ESmain, method="spearman")

        Spearman's rank correlation rho

data:  dataES$rdepth and dataES$ESmain
S = 36, p-value = 0.1511
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.5714286
```

To extract residuals we fitted a linear model to the dataset after excluding the two extreme points:

```
ESmain<-ESmain[-c(5, 26)]
ESdif<-ESdif[-c(5, 26)]
ESresid<-resid(lm(ESmain~ESdif))
```

And the tests looked as follows:

```
> cor.test(log(dataES$rdepth), dataES$ESresid)

        Pearson's product-moment correlation

data:  log(dataES$rdepth) and dataES$ESresid
t = 1.2437, df = 6, p-value = 0.26
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.3699887  0.8774637
sample estimates:
     cor
0.452717

> cor.test(dataES$rdepth, dataES$ESresid, method="spearman")

        Spearman's rank correlation rho

data:  dataES$rdepth and dataES$ESresid
S = 22, p-value = 0.04583
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.7380952
```

For our analyses we tried three more traits which we extracted from LEDA (). Specific Leaf Area (i.e. a representative of the Leaf Economic Spectrum), seed mass and species longevity.

For each species in LEDA that match our database we extracted the median value for the trait. The tests looked as follows:

```
> cor.test(ESmain, SLA, method="spearman")

        Spearman's rank correlation rho

data:  ESmain and SLA
S = 754, p-value = 0.7729
alternative hypothesis: true rho is not equal to 0
sample estimates:
      rho
0.07598039
```

Relationship with seed mass

```
> cor.test(ESmain, seedmass, method="spearman")

        Spearman's rank correlation rho

data:  ESmain and seedmass
S = 1222, p-value = 0.7335
alternative hypothesis: true rho is not equal to 0
sample estimates:
       rho
0.08120301
```

Relationship with longevity

```
> t.test(ESmain~longevity)

        Welch Two Sample t-test

data:  ESmain by longevity
t = -0.38196, df = 15.76, p-value = 0.7076
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.3342370  0.2322878
sample estimates:
   mean in group annuals mean in group perennials
              0.04602967               0.09700426
```

3. References

Guerrero-Ramirez N, Mommer L, Freschet GT, Iversen CM, McCormack M.L, Kattge J, Poorter H, van der Plas F, Bergmann J, Kuyper TW, York LM, Bruelheide H, Laughlin DC, Meier IC, Roumet C, Semchenko M, Sweeney CJ, van Ruijven J, Valverde-Barrantes OJ, Aubin I, Catford JA, Manning P, Martin A, Milla R, Minden V, Pausas JG, Smith SW, Soudzilovskaia NA, Ammer C, Butterfield B, Craine J, Cornelissen JHC, de Vries FT, Isaac ME, Kramer K, König C, Lamb EG, Onipchenko VG, Peñuelas J, Reich PB, Rillig MC, Sack L, Shipley B, Tedersoo L, Valladares F, van Bodegom P, Weigelt P, Wright JP, Weigelt A. 2021. Global Root Traits (GRooT) Database. Global Ecology and Biogeography 30: 25-37

Gurevitch J, Hedges LV. 1999. Statistical issues in ecological meta-analyses. Ecology 80: 1142-1149.

Kleyer M, Bekker R M, Knevel I C, Bakker J P, Thompson K, Sonnenschein M et al. 2008. The LEDA Traitbase: A database of life-history traits of Northwest European flora. Journal of Ecology 96, 1266-1274.

Lajeunesse MJ. 2011. On the meta-analysis of response ratios for studies with correlated and multi-group designs. Ecology 92: 2049-2055.

Viechtbauer W. 2010. Conducting meta-analyses in R with the metafor package. Journal of Statistical Software, 36(3), 1-48.

Appendix Two: Quality control considerations

1. Adherence by the PRISMA guidelines

(We only report here on the way our meta-analysis meets twelve of the key consideration criteria in the PRISMA guidelines)

1.1 Present the details of the search

We report on the database we used for the search and the exact search string.

1.2 Study inclusion and exclusion criteria

We report on the five inclusion criteria we used for the studies in our database.

1.3 PRISMA Flow Diagram

We present in the form of Fig. S2 a PRISMA flow diagram on our meta-analysis.

1.4 Data Extraction Process

We specify the software we used to extract data from figures when these were unavailable in tables or the main manuscript.

1.5 Weighting effect sizes

We specify the type and how we calculated both effect sizes and variances/weights

1.6 Specifying meta-analytical model

We specify that we used fixed-effects estimates based on the methods of moments and rationalize on their use based on the heterogeneity statistics

1.7 Dealing of heterogeneity

We specify heterogeneity statistics

1.8 Assessment of publication bias

We present funnel plots (Fig. S4) to address this point

1.9 Non-independence among study outcomes

We specify how we addressed violations of non-independence within studies

1.10 Specify the software used

We do so and specify the library we used. We additionally attach reproducible code.

1.11References

Because of the restrictions of the journal we cite the papers in the supplement (Appendix Three)

1.12 Data used for the meta-analysis

We included the data as a supplement

2. Power analysis

To carry out a power analysis of individual studies which we included in the meta-analysis we used the approach presented in Yang et al. (2021).

We calculated the true effect size based on the results of our meta-analysis as Δ_{PSF}=0.17. The standard error of this observation was 0.0255 (standard deviation can be extrapolated to 0.15). We then generated a hypothetical scenario of a study with *n*=10, which represented an average level of replication in our dataset. In such a scenario σ_s=0.47 and the critical *Z* value is 1.05. The statistical power of such a study is then 0.18 and the M error is 1.48 (Fig. S5).

To calculate the S error statistic which describes the probability that a significant statistic has the opposite sign that the one observed we used the estimates on significance and the direction of the effect from the forest plot in Fig. S3. Based on these estimates the observed S error statistic is 35% (Fig. S3).

3. Sensitivity analysis

3.1 Exclude One Sensitivity Analysis

We carried out a remove one sensitivity analysis and assessed two statistics from two meta-analyses. In one meta-analysis we checked whether the estimates for ΔPSF without any moderators overlapped zero and in the second whether in the meta-analysis with ΔPSF as a response and average PSF index as a predictor the moderator average PSF index was significant. We summarize the results in Fig. S5 and Fig. S6. In a nutshell none of the tests altered significance and there was no instance that the effect size after excluding a study differed from that with the study included.

4 Publication bias

To address publication bias we constructed funnel plots for both the tests using and that without moderators. We present results in Fig. S4.

5 Supplementary References

Yang Y, Hillebrand H, Lagisz M, Cleasby I, Nakagawa S. 2021. Low statistical power and overestimated anthropogenic impacts, exacerbated by publication bias, dominate field studies in global change biology. Global Change Biology 28: 969-989.

ID	Authors	Article Title	Source Title	training	type of index	plant species	measurement	ES drought	ES control	sd drought	sd control	n	microbes	parallel conditon
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Bidens frondosus	aboveground biomass	-0.40	-0.04	0.56	0.24	10		dry training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Bidens frondosus	aboveground biomass	-0.09	-0.30	1.49	0.73	10		dry training shade
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Bidens tripartitus	aboveground biomass	-0.36	-0.44	0.76	0.55	10		moist training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Bidens tripartitus	aboveground biomass	-0.32	0.39	0.33	1.08	10		moist training shade
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Epilobium adenocaulon	aboveground biomass	-0.70	-0.10	0.74	0.67	10		dry training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Epilobium adenocaulon	aboveground biomass	0.13	-0.11	0.99	0.48	10		dry training shade
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Epilobium obscurum	aboveground biomass	-0.35	0.05	0.92	0.55	10		moist training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Epilobium obscurum	aboveground biomass	-0.19	-0.14	0.36	0.87	10		moist training shade
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Sisymbrium loeselii	aboveground biomass	-0.87	-0.09	1.81	0.33	10		dry training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Sisymbrium loeselii	aboveground biomass	-0.01	-0.03	0.98	0.50	10		dry training shade
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Sisymbrium officinale	aboveground biomass	-1.15	-0.59	1.24	0.42	10		moist training light
2	Aldorfova; Anna; Munzbergova; Zuzana	Conditions of plant cultivation affect the differences in intraspecific plant-soil feedback between invasive and native dominants	FLORA	yes	PSF index; ln(plan	Sisymbrium officinale	aboveground biomass	-0.16	-0.39	0.77	0.42	10		moist training shade

5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens parviflora	biomass	0.10	0.48	0.41	0.64	10		shade
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens parviflora	biomass	0.08	0.04	0.35	0.19	10		light
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens balfourii	biomass	0.04	0.29	0.53	0.80	10		shade
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens balfourii	biomass	0.45	0.15	0.60	0.25	10		light
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens balsamina	biomass	-0.11	0.79	0.36	0.99	10		shade
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens balsamina	biomass	0.29	-0.31	0.36	0.23	10		light
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens scabrida	biomass	0.29	0.02	0.34	0.80	10		shade
5	Florianova; Anna; Munzbergova; Zuzana	The intensity of intraspecific plant-soil feedbacks in alien Impatiens species depends on the environment	PERSPECTIV	yes	PSF index; ln(plan	Impatiens scabrida	biomass	-0.02	0.18	0.68	0.23	10		light
3	Crawford; Kerri M.; Hawkes; Christine; V	Soil precipitation legacies influence intraspecific plant-soil feedback	ECOLOGY	yes	pairwise PSF; (ow	Panicum virgatum	aboveground biomass	-2.21	-0.40	0.90	0.91	7		
3	Crawford; Kerri M.; Hawkes; Christine; V	Soil precipitation legacies influence intraspecific plant-soil feedback	ECOLOGY	yes	pairwise PSF; (ow	Panicum virgatum	aboveground biomass	-1.56	-0.72	0.87	0.89	7		
3	Crawford; Kerri M.; Hawkes; Christine; V	Soil precipitation legacies influence intraspecific plant-soil feedback	ECOLOGY	yes	pairwise PSF; (ow	Panicum virgatum	aboveground biomass	-0.54	-2.99	0.86	0.87	7		
7	Hahn; Philip G.; Buffington; Lorinda; Larkin; Beau; LaFlamme; Kelly; Maron; John L.; Lekberg; Ylva	Effects of Short- and Long-Term Variation in Resource Conditions on Soil Fungal Communities and Plant Responses to Soil Biota	FRONTIERS	yes	log response ratio	Asclepias speciosa	aboveground biomass	0.14	-0.18	0.08	0.06	25		WA site

7	Hahn; Philip G.; Buffington; Lorinda; Larkin; Beau; LaFlamme; Kelly; Maron; John L.; Lekberg; Ylva	Effects of Short- and Long-Term Variation in Resource Conditions on Soil Fungal Communities and Plant Responses to Soil Biota	FRONTIERS	yes	log response ratio	Asclepias speciosa	aboveground biomass	0.21	-0.23	0.06	0.20	25		MN site
11	Koorem; Kadri; Wilschut; Rutger A.; Weser; Carolin; van der Putten; Wim H.	Disentangling nematode and arbuscular mycorrhizal fungal community effect on the growth of range-expanding Centaurea stoebe in original and new range soil	PLANT AND	yes	PSF index; ln(trea	Centaurea jacea	aboveground biomass	0.67	0.52	0.65	0.44	5	(native) Centaurea jacea cultivated	
11	Koorem; Kadri; Wilschut; Rutger A.; Weser; Carolin; van der Putten; Wim H.	Disentangling nematode and arbuscular mycorrhizal fungal community effect on the growth of range-expanding Centaurea stoebe in original and new range soil	PLANT AND	yes	PSF index; ln(trea	Centaurea jacea	aboveground biomass	0.75	0.32	0.20	0.23	5	(range-expanding) Centaurea stoebe cultivated	
11	Koorem; Kadri; Wilschut; Rutger A.; Weser; Carolin; van der Putten; Wim H.	Disentangling nematode and arbuscular mycorrhizal fungal community effect on the growth of range-expanding Centaurea stoebe in original and new range soil	PLANT AND	yes	PSF index; ln(trea	Centaurea stoebe	aboveground biomass	1.10	0.44	0.32	0.45	5	(native) Centaurea jacea cultivated	
11	Koorem; Kadri; Wilschut; Rutger A.; Weser; Carolin; van der Putten; Wim H.	Disentangling nematode and arbuscular mycorrhizal fungal community effect on the growth of range-expanding Centaurea stoebe in original and new range soil	PLANT AND	yes	PSF index; ln(trea	Centaurea stoebe	aboveground biomass	0.58	0.29	0.42	0.20	5	(range-expanding) Centaurea stoebe cultivated	
12	Meijer; Seline S.; Holmgren; Milena; Van der Putten; Wim H.	Effects of plant-soil feedback on tree seedling growth under arid conditions	JOURNAL OF	yes	PSF index; ln(trea	Prosopis pallida & P. chilensis	aboveground biomass	0.17	0.06	0.52	0.73	27		
13	Remke; Michael J.; Johnson; Nancy C.; Wright; Jeffrey; Williamson; Matthew; Bowker; Matthew A.	Sympatric pairings of dryland grass populations; mycorrhizal fungi and associated soil biota enhance mutualism and ameliorate drought stress	JOURNAL OF	yes	log response ratio	Bouteloua gracilis	total biomass	-0.22	-0.46	0.06	0.04	9	microbes from wet, plants from dry	treatments are referred to as moderate and extreme drought
13	Remke; Michael J.; Johnson; Nancy C.; Wright; Jeffrey; Williamson; Matthew; Bowker; Matthew A.	Sympatric pairings of dryland grass populations; mycorrhizal fungi and associated soil biota enhance mutualism and ameliorate drought stress	JOURNAL OF	yes	log response ratio	Bouteloua gracilis	total biomass	0.60	0.31	0.07	0.05	9	microbes from dry, plants from dry	treatments are referred to as moderate and extreme drought

13	Remke; Michael J.; Johnson; Nancy C.; Wright; Jeffrey; Williamson; Matthew; Bowker; Matthew A.	Sympatric pairings of dryland grass populations; mycorrhizal fungi and associated soil biota enhance mutualism and ameliorate drought stress	JOURNAL OI	yes	log response ratio	Bouteloua gracilis	total biomass	0.25	0.19	0.03	0.07	9	microbes from wet, plants from wet	treatments are referred to as moderate and extreme drought
13	Remke; Michael J.; Johnson; Nancy C.; Wright; Jeffrey; Williamson; Matthew; Bowker; Matthew A.	Sympatric pairings of dryland grass populations; mycorrhizal fungi and associated soil biota enhance mutualism and ameliorate drought stress	JOURNAL OI	yes	log response ratio	Bouteloua gracilis	total biomass	-0.55	-0.76	0.03	0.07	9	microbes from dry plants from wet	treatments are referred to as moderate and extreme drought
16	Valliere; Justin M.; Allen; Edith B.	Interactive effects of nitrogen deposition and drought-stress on plant-soil feedbacks of Artemisia californica seedlings	PLANT AND	yes	(live - mean of ste	Artemisia californica	biomass	0.99	-0.51	0.50	0.16	10	low N depisition soil	low nitrogen
16	Valliere; Justin M.; Allen; Edith B.	Interactive effects of nitrogen deposition and drought-stress on plant-soil feedbacks of Artemisia californica seedlings	PLANT AND	yes	(live - mean of ste	Artemisia californica	biomass	-0.45	-0.89	0.20	0.23	10	high N deposition soil	low nitrogen
16	Valliere; Justin M.; Allen; Edith B.	Interactive effects of nitrogen deposition and drought-stress on plant-soil feedbacks of Artemisia californica seedlings	PLANT AND	yes	(live - mean of ste	Artemisia californica	biomass	0.10	-0.44	0.35	0.14	10	low N depisition soil	high nitrogen
16	Valliere; Justin M.; Allen; Edith B.	Interactive effects of nitrogen deposition and drought-stress on plant-soil feedbacks of Artemisia californica seedlings	PLANT AND	yes	(live - mean of ste	Artemisia californica	biomass	-0.34	0.26	0.36	0.06	10	high N deposition soil	high nitrogen
18	Xi; Nianxun; Chu; Chengjin; Bloor; Juliette M. G.	Plant drought resistance is mediated by soil microbial community structure and soil-plant feedbacks in a savanna tree species	ENVIRONME	yes	(live - mean of ste	Bauhinia brachycarpa	shoot biomass	-0.23	-0.46	0.10	0.11	6		
1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	0.03	-0.69	0.26	0.26	10	north	low nutrients
1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	0.30	-0.11	0.28	0.17	10	south	low nutrients
1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	0.49	0.25	0.26	0.13	10	mixed	low nutrients
1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	0.54	-0.65	0.29	0.21	10	north	high nutrients

1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	0.83	0.32	0.29	0.15	10	south	high nutrients
1	Adomako, Michael Opoku; Xue, Wei; Tang, Min; Du, Dao-Lin; Yu, Fei-Hai	Synergistic Effects of Soil Microbes onSolidago canadensisDepend on Water and Nutrient Availability	MICROBIAL I	yes	log response ratio	Solidago canadensis	aboveground biomass g	1.52	0.59	0.29	0.14	10	mixed	high nutrients
4	Fitzpatrick, Connor R.; Mustafa, Zainab; Viliunas, Joani	Soil microbes alter plant fitness under competition and drought	JOURNAL OI	yes	log response ratio	Arabidopsis thaliana	total seed production	0.10	-0.12	0.07	0.08	38		
6	Fry, Ellen L.; Johnson, Giles N.; Hall, Amy L.; Pritchard, W. James; Bullock, James M.; Bardgett, Richard D.	Drought neutralises plant-soil feedback of two mesic grassland forbs	OECOLOGIA	yes	log response ratio	Scabiosa columbaria	shoot mass g	-0.09	-0.70	0.20	0.34	5	conspecific soil	
6	Fry, Ellen L.; Johnson, Giles N.; Hall, Amy L.; Pritchard, W. James; Bullock, James M.; Bardgett, Richard D.	Drought neutralises plant-soil feedback of two mesic grassland forbs	OECOLOGIA	no	log response ratio	Scabiosa columbaria	shoot mass g	-0.51	0.00	0.24	0.21	5	heterospecific soil (cultivated by Sanguisorba minor)	
6	Fry, Ellen L.; Johnson, Giles N.; Hall, Amy L.; Pritchard, W. James; Bullock, James M.; Bardgett, Richard D.	Drought neutralises plant-soil feedback of two mesic grassland forbs	OECOLOGIA	yes	log response ratio	Sanguisorba minor	shoot mass g	0.06	0.12	0.34	0.13	5	conspecific soil	
6	Fry, Ellen L.; Johnson, Giles N.; Hall, Amy L.; Pritchard, W. James; Bullock, James M.; Bardgett, Richard D.	Drought neutralises plant-soil feedback of two mesic grassland forbs	OECOLOGIA	no	log response ratio	Sanguisorba minor	shoot mass g	0.01	-0.05	0.17	0.11	5	heterospecific soil (cultivated by Sanguisorba minor)	

8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	yes	log response ratio	Schizachyrium scoparium	aboveground biomass	-0.08	-0.39	0.56	0.39	7	Schizachyrium scoparium soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Schizachyrium scoparium	aboveground biomass	-0.11	-0.46	0.67	0.59	7	Rudbeckia hirta soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Schizachyrium scoparium	aboveground biomass	-3.12	-1.68	1.02	1.29	7	Plantago lanceolata soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Rudbeckia hirta	aboveground biomass	-0.52	-0.36	0.44	0.38	7	Schizachyrium scoparium soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	yes	log response ratio	Rudbeckia hirta	aboveground biomass	-0.43	-0.11	0.49	0.47	7	Rudbeckia hirta soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Rudbeckia hirta	aboveground biomass	0.24	0.09	0.66	0.77	7	Plantago lanceolata soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Plantago lanceolata	aboveground biomass	-0.25	0.02	0.30	0.35	7	Schizachyrium scoparium soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	no	log response ratio	Plantago lanceolata	aboveground biomass	0.53	0.73	0.25	0.32	7	Rudbeckia hirta soil	
8	Hawkins, Anna P.; Crawford, Kerri M.	Interactions between plants and soil microbes may alter the relative importance of intraspecific and interspecific plant competition in a changing climate	AOB PLANTS	yes	log response ratio	Plantago lanceolata	aboveground biomass	-0.67	-0.13	0.36	0.56	7	Plantago lanceolata soil	
9	Heinze, Johannes; Gensch, Sabine; Weber, Ewald; Joshi, Jasmin	Soil temperature modifies effects of soil biota on plant growth	JOURNAL OF	yes	log response ratio	Dactylis glomerata	shoot biomass g	0.09	0.08	0.11	0.11	15		
15	Snyder, Amelia E.; Harmon-Threatt, Alexandra N.	Reduced water-availability lowers the strength of negative plant-soil feedbacks of two Asclepias species	OECOLOGIA	yes	log response ratio	Asclepias syriaca	biomass (LS)	0.63	-0.81	1.24	0.13	4	Asclepias syriaca soil	
15	Snyder, Amelia E.; Harmon-Threatt, Alexandra N.	Reduced water-availability lowers the strength of negative plant-soil feedbacks of two Asclepias species	OECOLOGIA	no	log response ratio	Asclepias syriaca	biomass (LS)	0.94	-0.23	1.24	0.12	4	Asclepias sullivantii soil	
15	Snyder, Amelia E.; Harmon-Threatt, Alexandra N.	Reduced water-availability lowers the strength of negative plant-soil feedbacks of two Asclepias species	OECOLOGIA	no	log response ratio	Asclepias sullivantii	biomass (LS)	0.68	-0.43	1.24	0.13	4	Asclepias syriaca soil	

15	Snyder, Amelia E.; Harmon-Threatt, Alexandra N.	Reduced water-availability lowers the strength of negative plant-soil feedbacks of two Asclepias species	OECOLOGIA	yes	log response ratio	Asclepias sullivantii	biomass (LS)	0.40	0.01	1.24	0.15	4	Asclepias sullivantii soil	
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium dissectum	shoot biomass g	-0.27	-0.31	0.35	0.24	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium molle	shoot biomass g	0.32	-0.22	0.35	0.27	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium purpureum	shoot biomass g	-0.43	-0.38	0.40	0.18	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium pusillum	shoot biomass g	-0.45	-0.18	0.42	0.36	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium pyrenaicum	shoot biomass g	0.17	0.04	0.28	0.11	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium robertianum	shoot biomass g	-0.07	-0.22	0.41	0.12	5		
17	Wilschut, Rutger A.; van Kleunen, Mark	Drought alters plant-soil feedback effects on biomass allocation but not on plant performance	PLANT AND	yes	log response ratio	Geranium rotundifolium	shoot biomass g	-0.53	-0.53	0.44	0.16	5		

Appendix Four

1. Koorem K, Wilschut RA, Weser C, van der Putten WH. 2021. Disentangling nematode and arbuscular mycorrhizal fungal community effect on the growth of range-expanding Centaurea stoebe in original and new range soil. Plant and Soil 466: 207-221

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