Notes S2 Meta-analysis of ecosystem experiments

Notes S2.1 Statistical analysis

The natural logarithm of the response ratio of the means and its variance were calculated for each response variable, experiment, treatment, and sampling year, using information about the the number of repeated measurements (multiple experimental plots, multiple sampling dates per year). This was done using the function `escalc(measure="ROM", ...)` from the {metafor} R package (Viechtbauer, 2010). The standard error was calculated as $\mathrm{SE} = \sqrt{\mathrm{var}/N}$, where N is the number of repeated measurements.

For CO_2 experiments, the response ratio was normalised with (divided by) the natural logarithm of the ratio of elevated over ambient CO_2 concentrations.

Data was then aggregated by experiment using the procedure based on Borenstein (2009), implemented by the function `agg(method = "BHHR", ...)` from the {MAd} R package (Hoyt, 2014), and assuming a correlation of within-study response ratios of 0.5.

Finally, the meta-analysis of responses across experiments was performed as a mixed-effects meta-regression model using experiment as the grouping variable for random factors, and fitted via the restricted maximum likelihood esimation. This is implemented using the function `rma.mv(method = "REML", ...)` from the {metafor} R package (Viechtbauer, 2010). The confidence intervals (edges of boxes in Fig. 3) of the meta-analytic mean response ratio (bold line inside boxes in Fig. 3) span 95%.

Notes S2.2 Response to CO2, MESI data

Notes S2.2.1 Data selection

Data were used from the Manipulation Experiments Synthesis Initiative (MESI) database (Van Sundert et al., 2023), obtained from GitHub (`https://github.com/MESI-organization/mesi-db`). For CO_2 experiments, we considered only data from Free Air CO_2 Enrichment (FACE) experiments and from open-top chamber experiments, from experiments that provided data from at least three years. For data generated in multi-factorial experiments, we used only data from the CO_2-only treatment (no interactions with other experimentally manipulated factors considered). Variables shown in this manuscript (Fig. 3, 4, and 6 in this study) were identified by the response variable name in the database according to Tab. 1.

Notes S2.2.2 Extended results

Table 1: Variables in the MESI database used for the analysis.

Variable name	Variable code	Variable names in MESI
AGB	agb	agb_coarse, agb
BGB	bgb	bgb, fine_root_biomass, coarse_root_c_stock, bgb_coarse
LAI	lai	lai, lai_max
Root NPP	root_production	root_production, fine_root_production, coarse_root_production
N uptake	n_uptake	root_n_uptake, root_nh4_uptake, root_no3_uptake
Inorganic N	n_inorg	soil_no3-n, soil_nh4-n, soil_nh4, soil_no3, soil_solution_nh4, soil_solution_no3
A_{sat}	asat	asat
V_{cmax}	vcmax	vcmax
J_{max}	jmax	jmax
GPP	gpp	gpp
N_{area}	leaf_n_area	leaf_n_area
N_{mass}	leaf_n_mass	leaf_n_mass
Leaf C:N	leaf_cn	leaf_cn
ANPP	anpp	anpp
Root:shoot	root_shoot_ratio	root_shoot_ratio

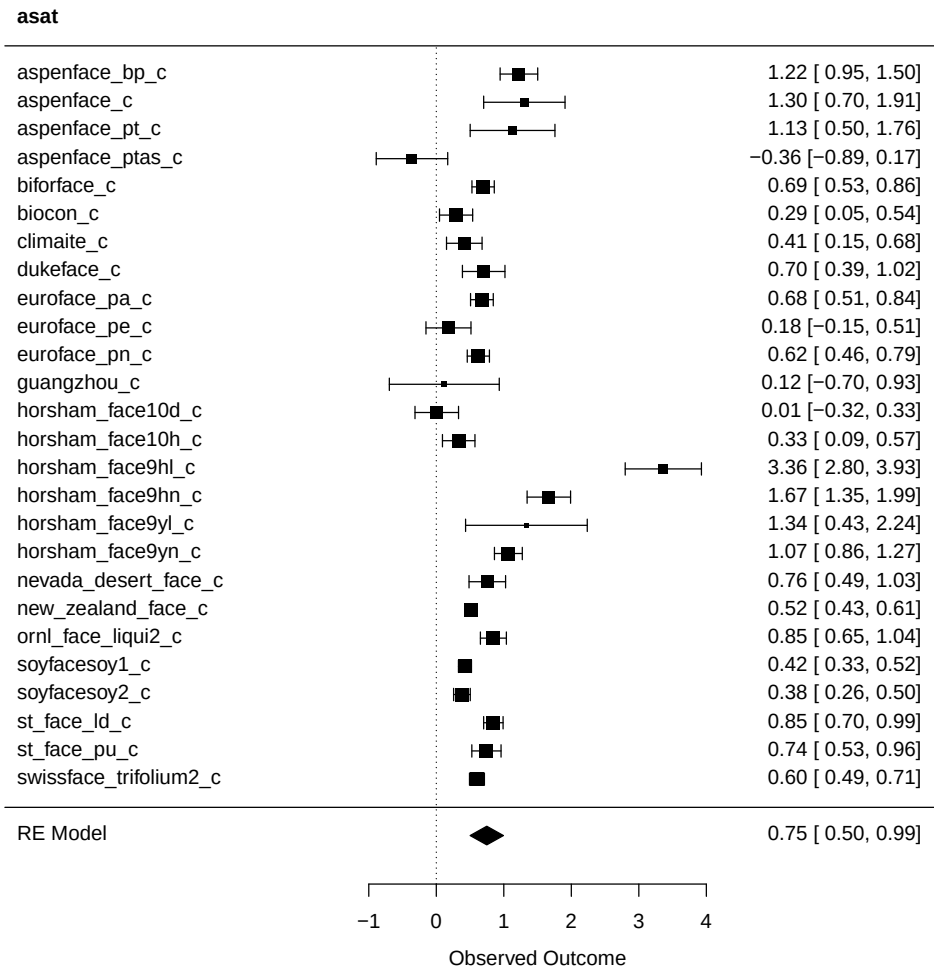

Figure 1: Response of leaf-level assimilation under light-saturated conditions (A_{sat}) to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

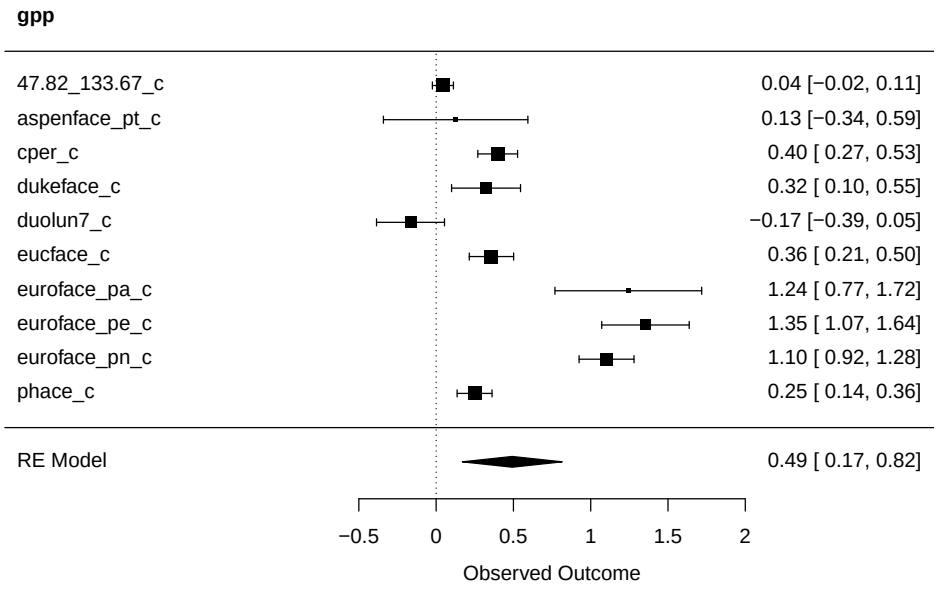

Figure 2: Response of GPP to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

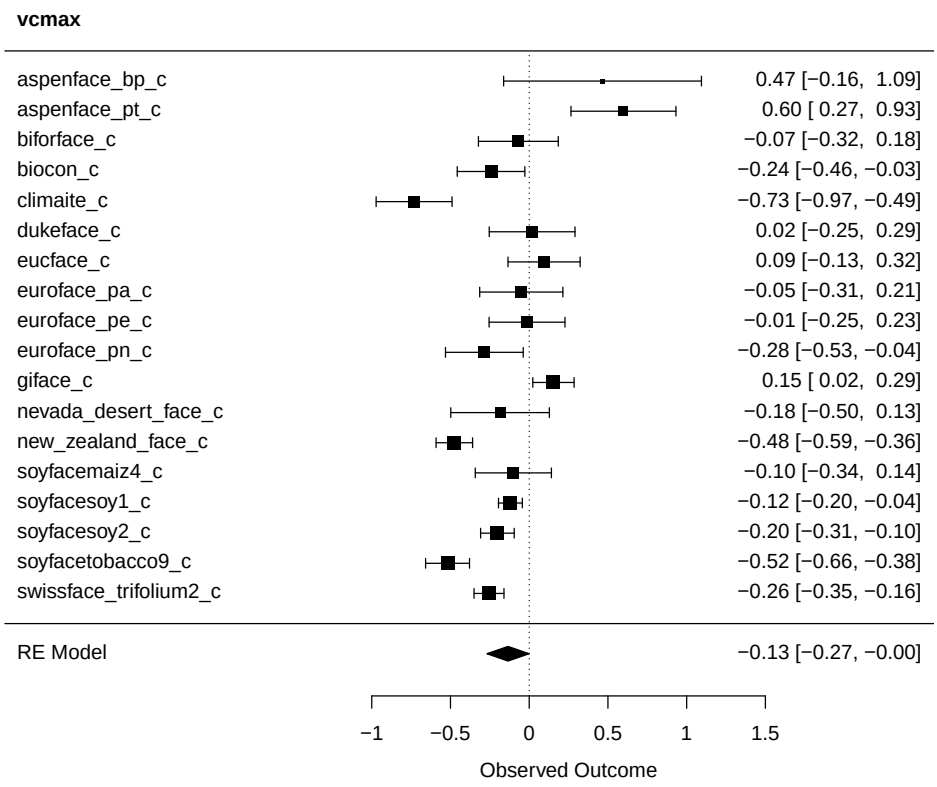

Figure 3: Response of V_{cmax} to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

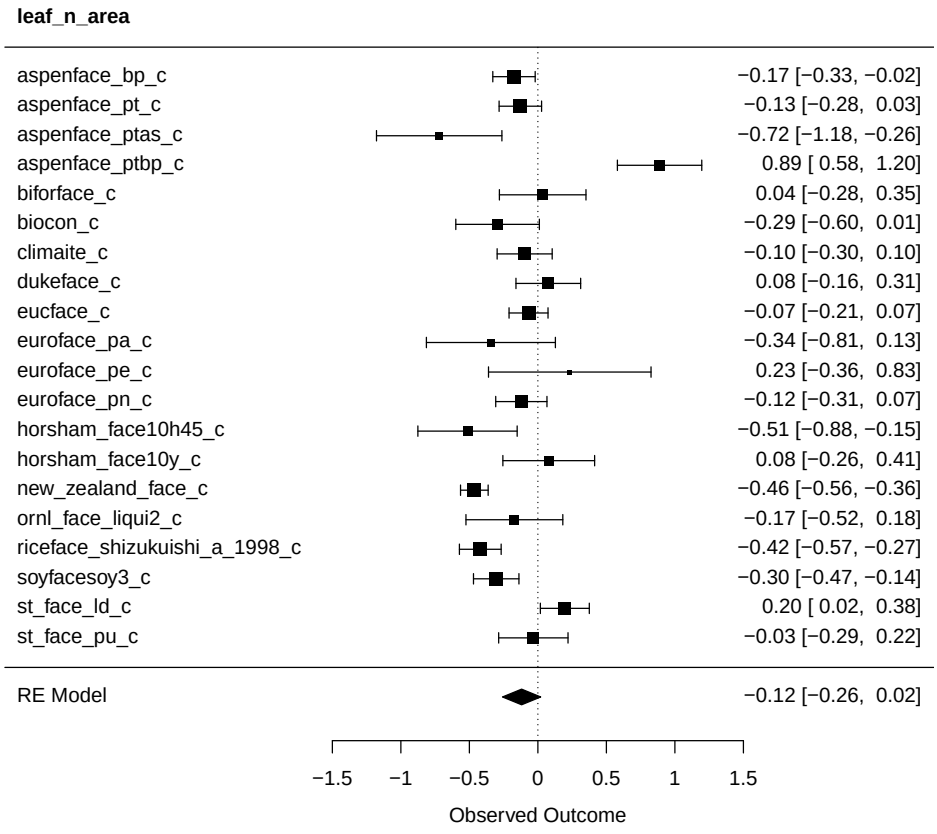

Figure 4: Response of leaf N_{area} to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

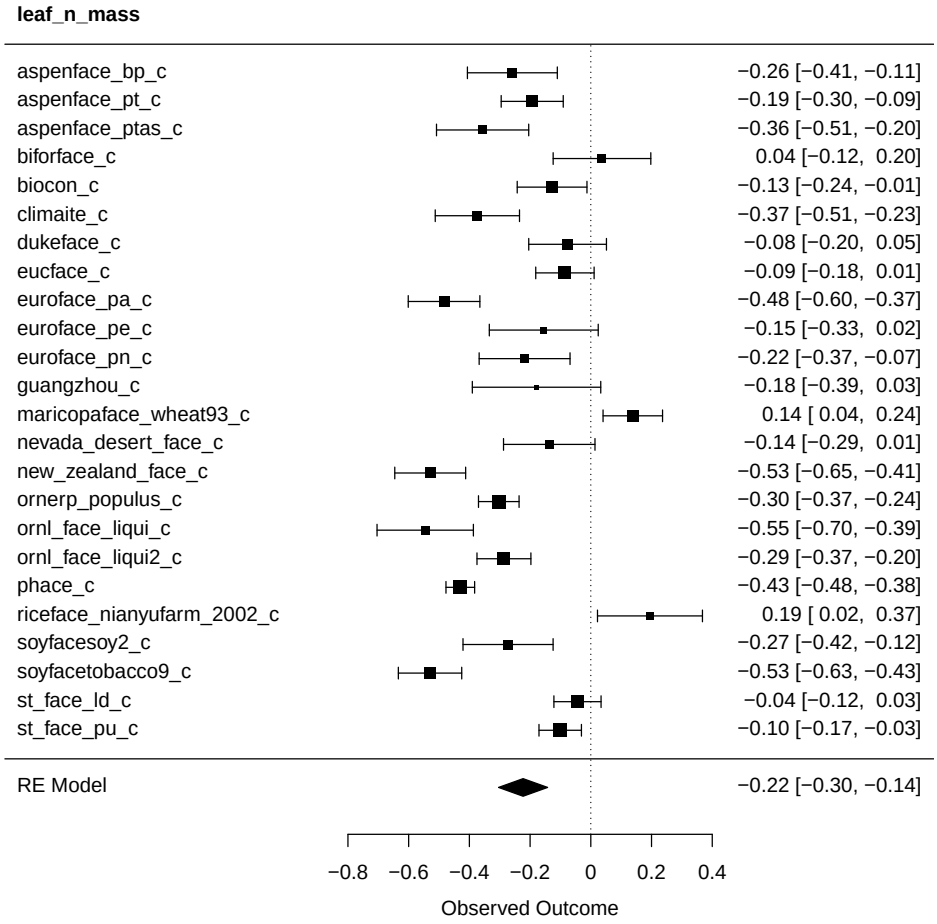

Figure 5: Response of leaf N_{mass} to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

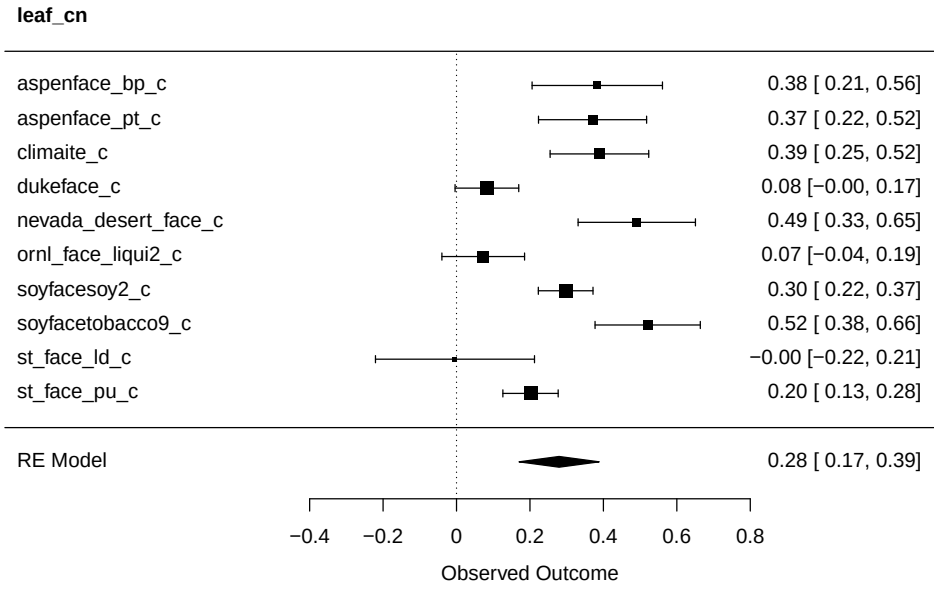

Figure 6: Response of leaf C:N to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

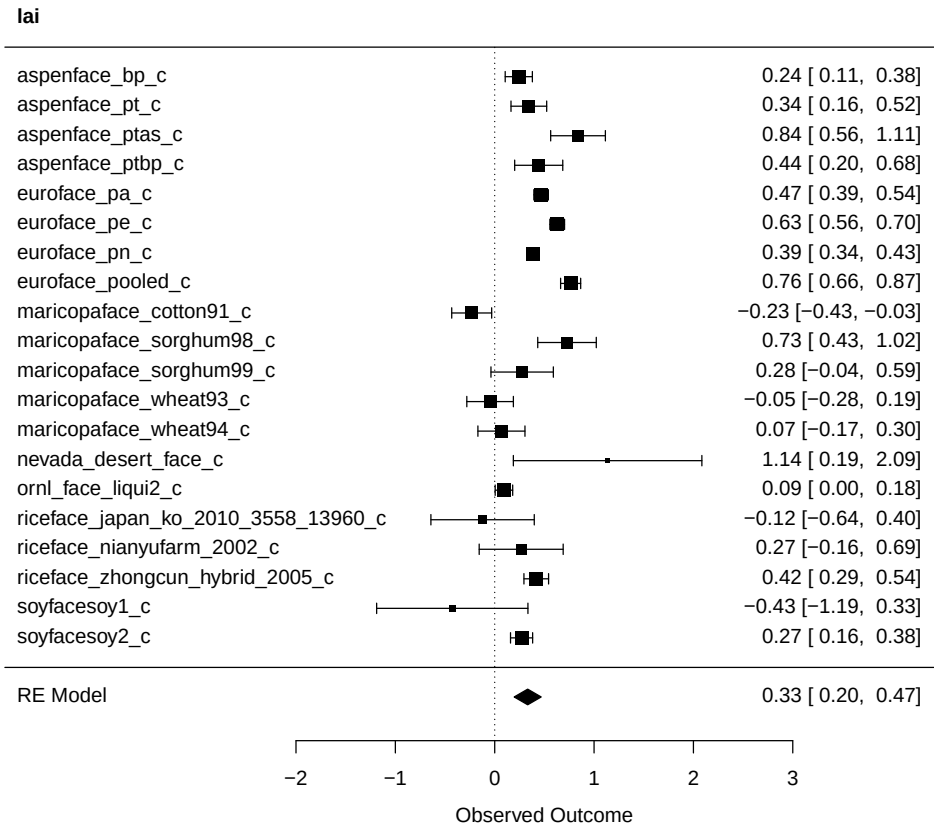

Figure 7: Response of LAI to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

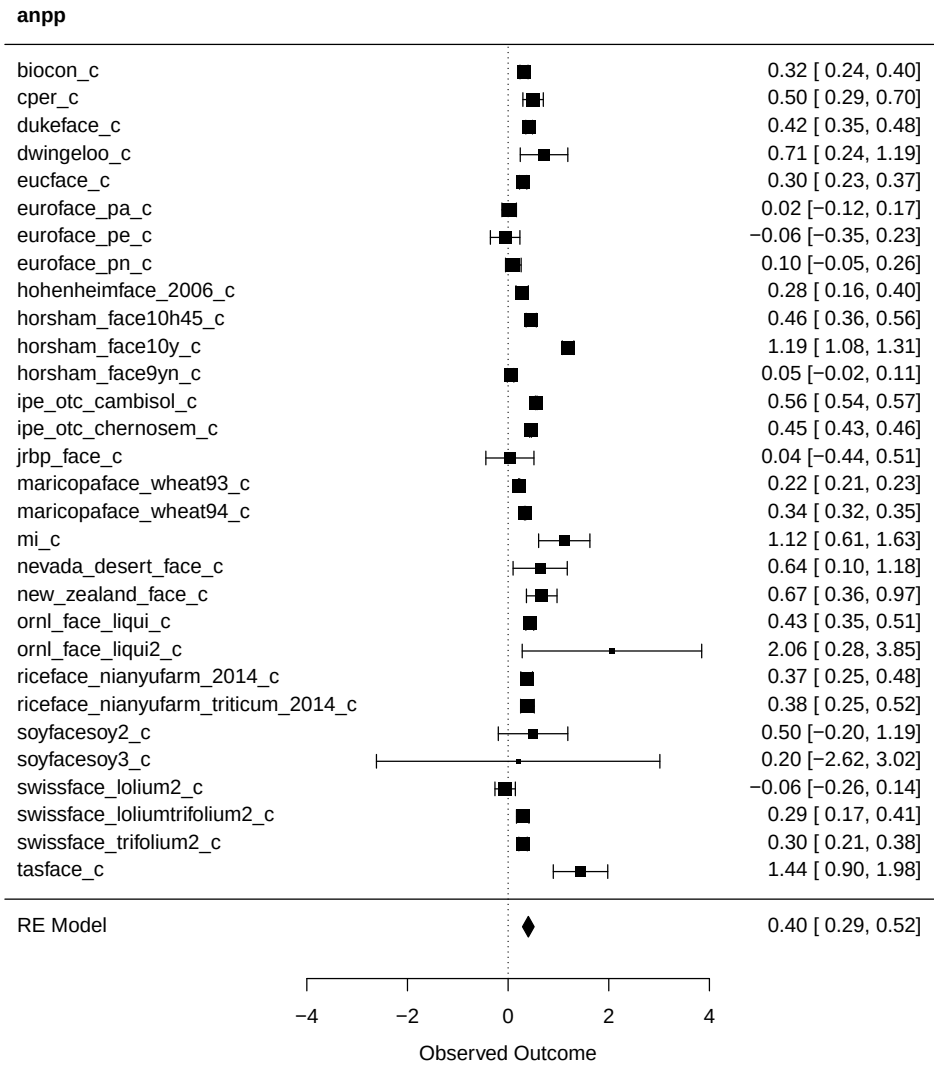

Figure 8: Response of aboveground net primary productivity (ANPP) to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

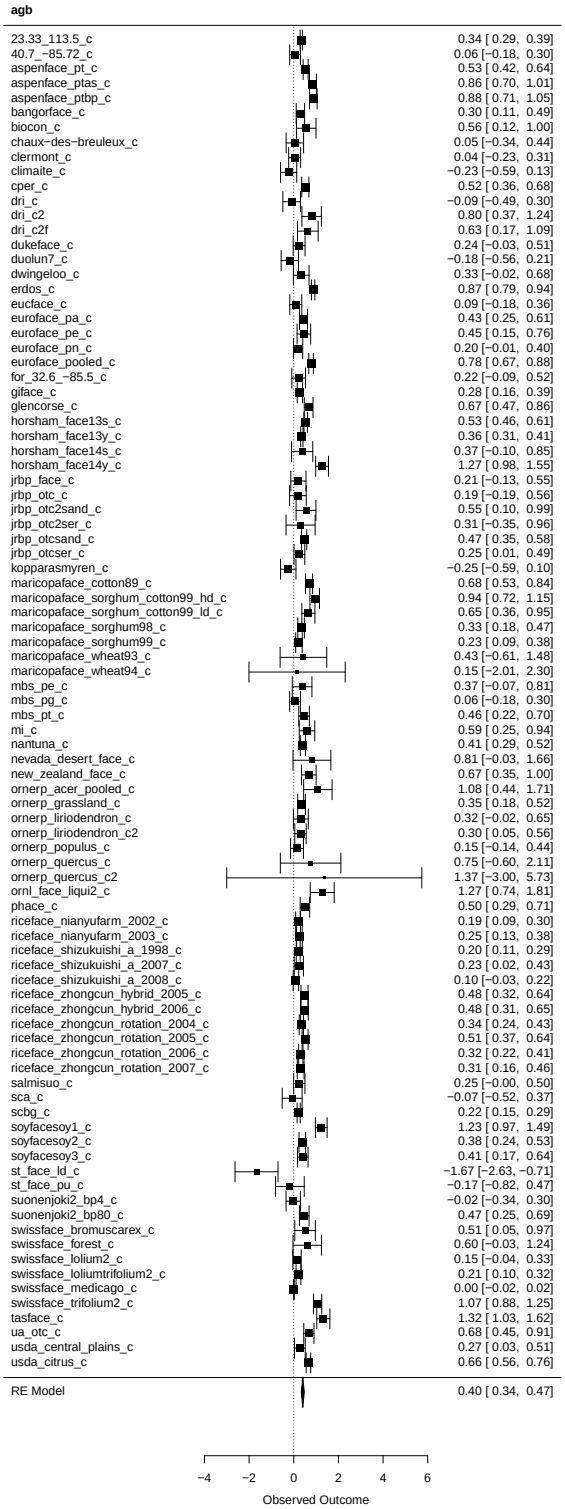

Figure 9: Response of aboveground biomass (AGB) to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

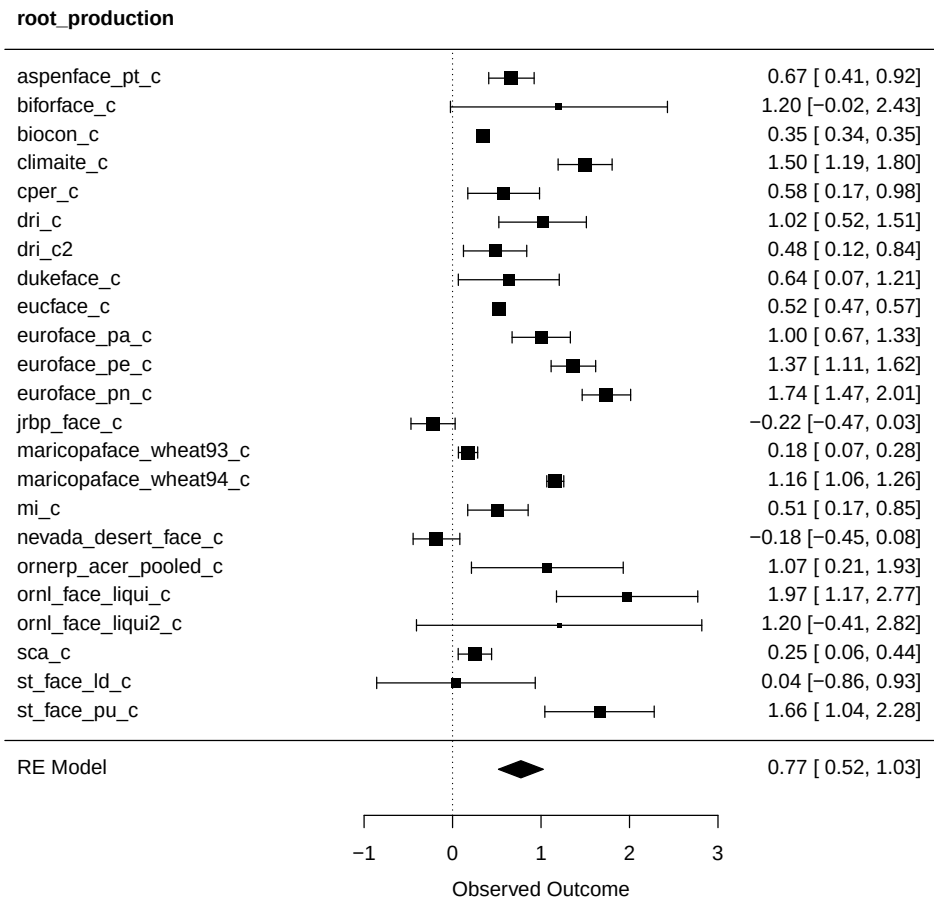

Figure 10: Response of root biomass productivity to elevated CO_2 in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

Notes S2.3 Response to N-fertilisation, MESI and NutNet data

Notes S2.3.1 Data selection

Data were used from the Manipulation Experiments Synthesis Initiative (MESI) database (Van Sundert et al., 2023), obtained from GitHub (`https://github.com/MESI-organization/mesi-db`). For variables belowground biomass (bgb, `Rootsgperm2` in NutNet), root mass fraction (rmf, `rootmassfraction` in NutNet), aboveground biomass (agb), and the root:shoot ratio (root_shoot_ratio), we combined MESI data with data from the meta-analysis of the NutNet experiments network by Cleland et al. (2019). Aboveground biomass from NutNet data was calculated as (bgb/rmf) − bgb. The root:shoot ratio from NutNet data was calculated as bgb/agb.

For MESI data, only data from field experiments were used for which the N application rate was less or equal to 300 kg N ha^{-1} yr^{-1}. For data generated in multifactorial experiments, we used only data from the N-fertilisation-only treatment (no interactions with other experimentally manipulated factors considered). Variables shown in this manuscript (Fig. 3, 4, and 6 in this study) were identified by the response variable name in the database according to Tab. 1.

Notes S2.3.2 Extended results

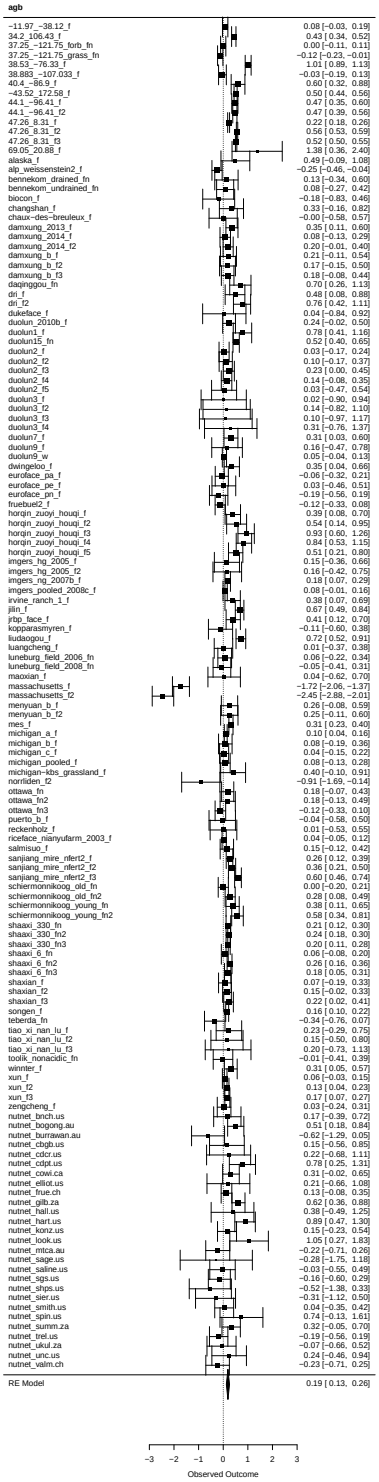

Figure 11: Response of aboveground biomass (agb) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

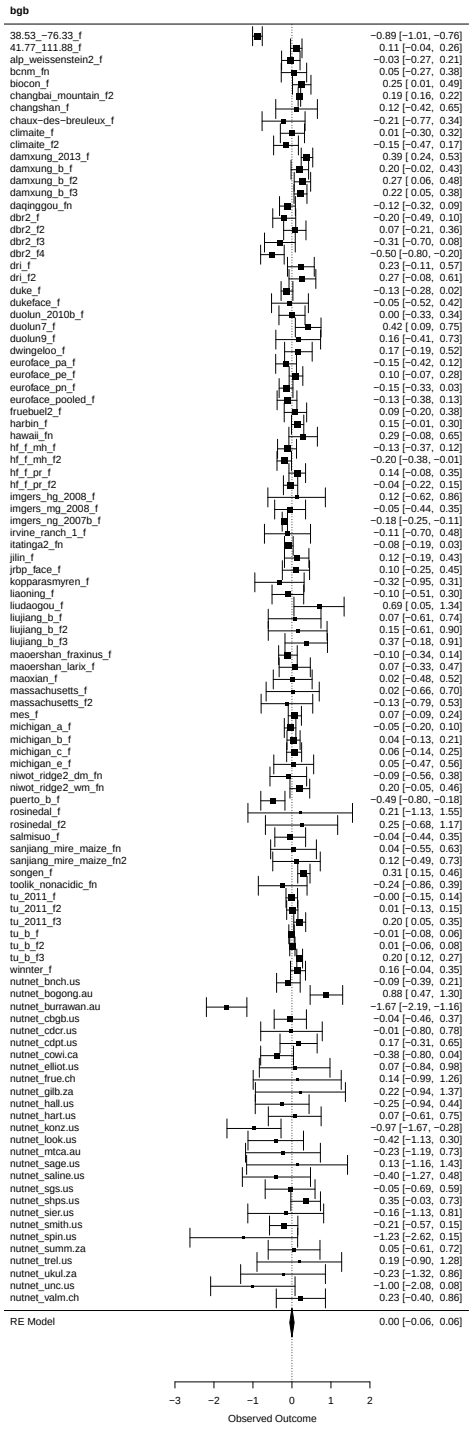

Figure 12: Response of belowground biomass (bgb) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

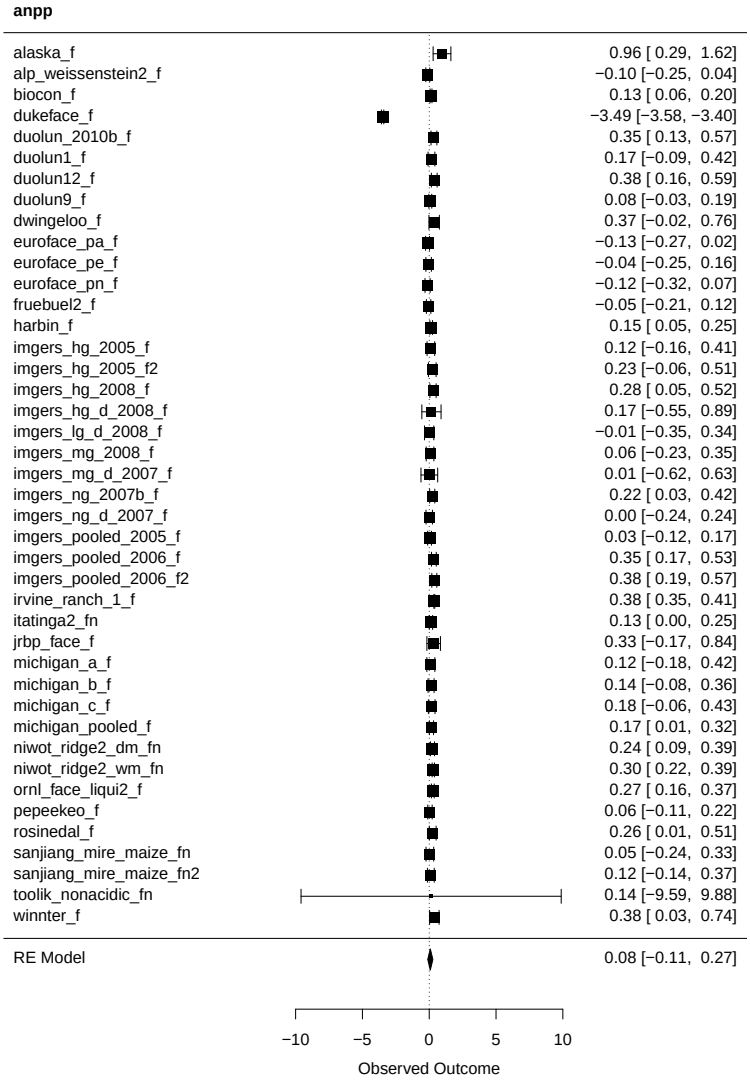

Figure 13: Response of aboveground net primariy production (anpp) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

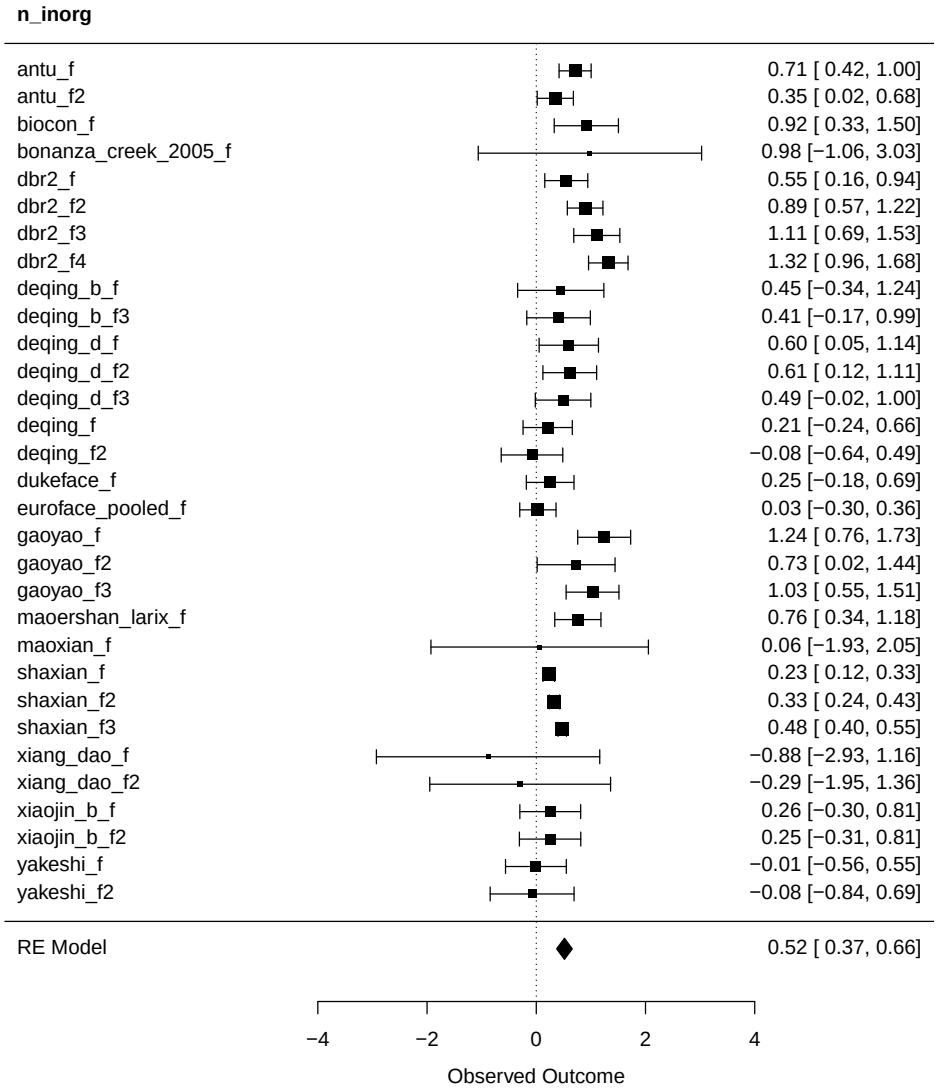

Figure 14: Response of soil inorganic nitrogen (n_inorg) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

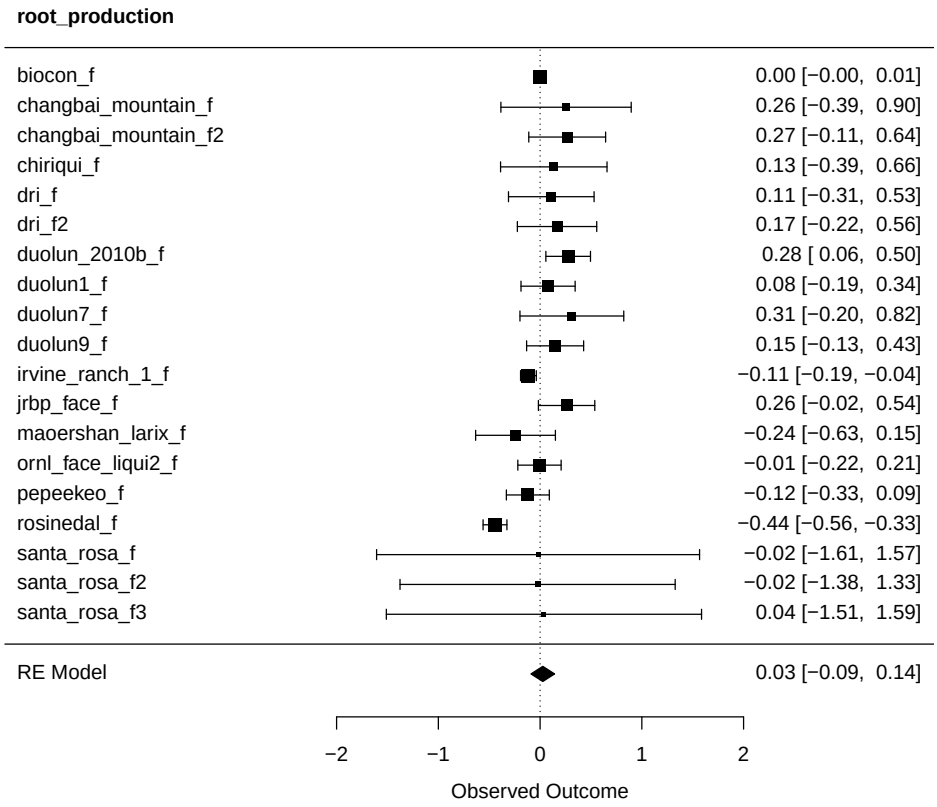

Figure 15: Response of root biomass production (root_production) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

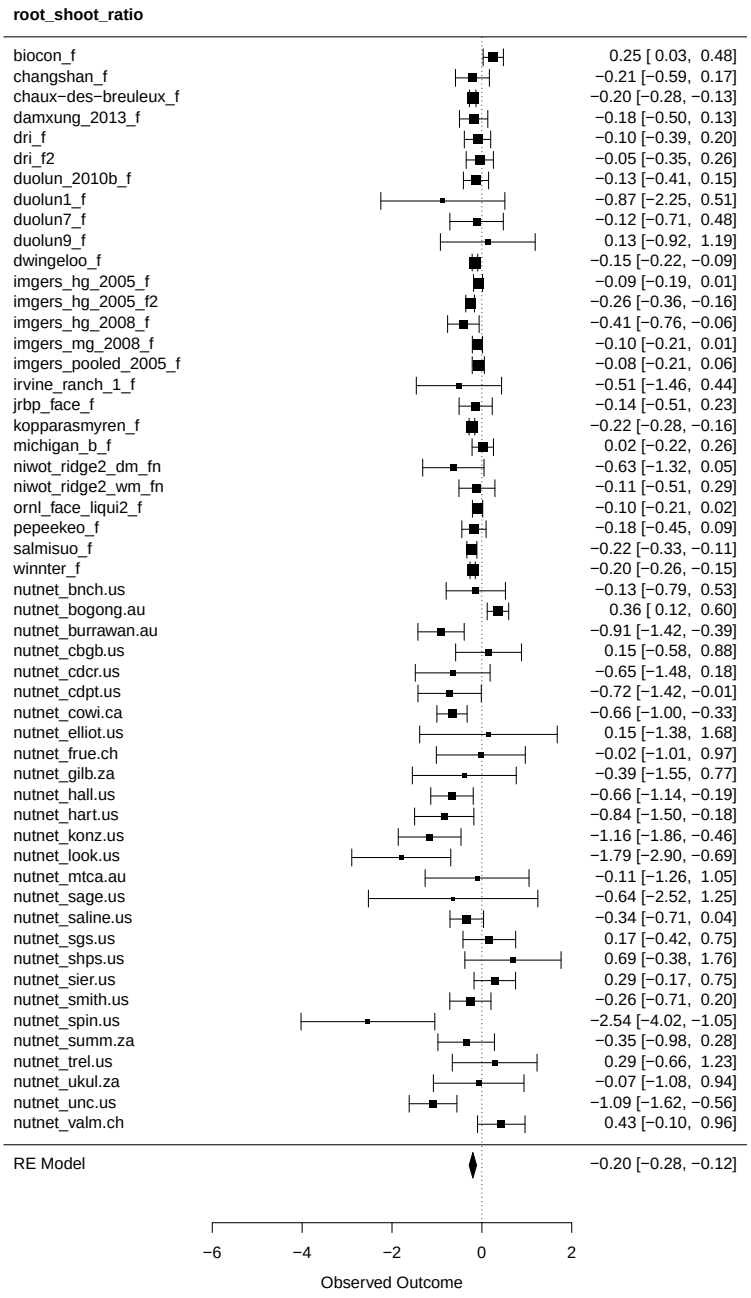

Figure 16: Response of the root:shoot ratio (root_shoot_ratio) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

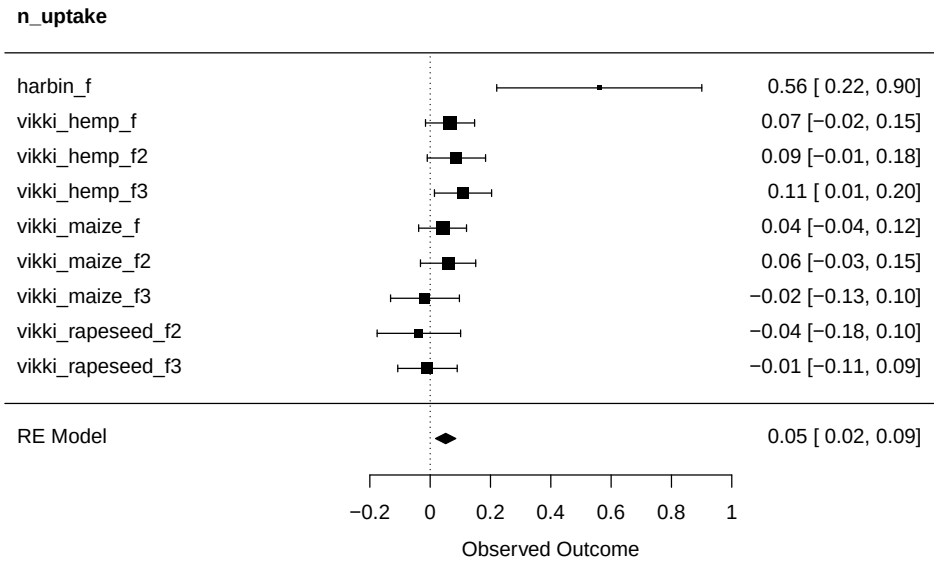

Figure 17: Response of the N uptake ratio (n_uptake) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

Notes S2.4 Response to N-fertilisation, Liang et al. data

Notes S2.4.1 Data selection

Data were used from the meta-analysis by Liang et al. (2020) for which the N application rate was less or equal to 300 kg N ha^{-1} yr^{-1}.

Notes S2.4.2 Extended results

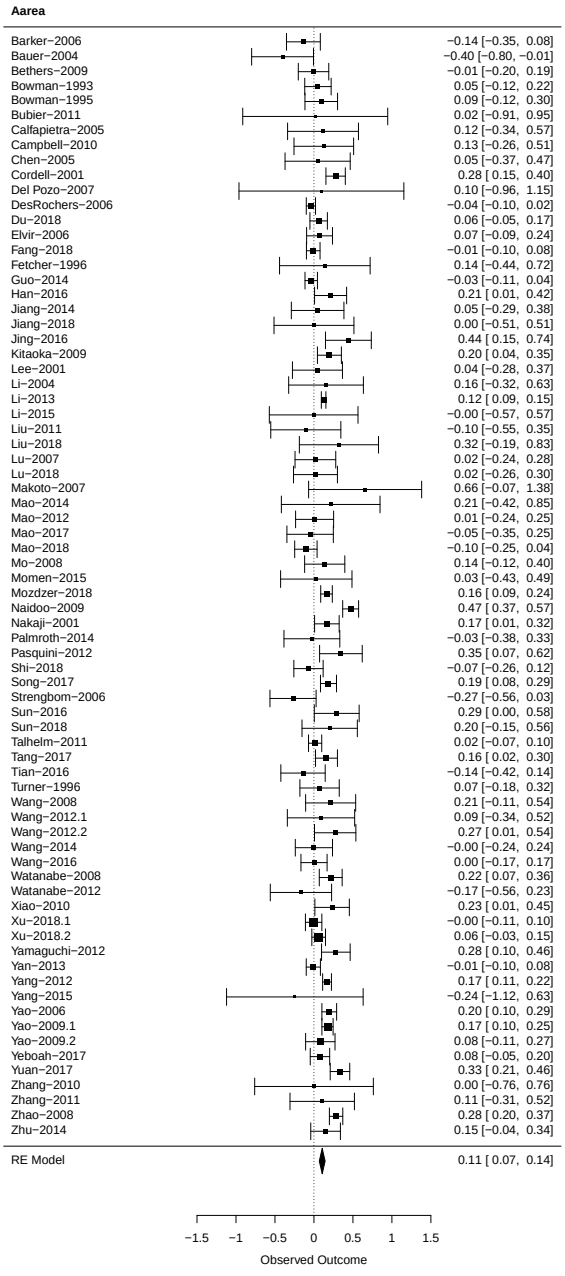

Figure 18: Response of leaf-level assimilation rate (Aarea), here interpreted as representative for light-saturated conditions, to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

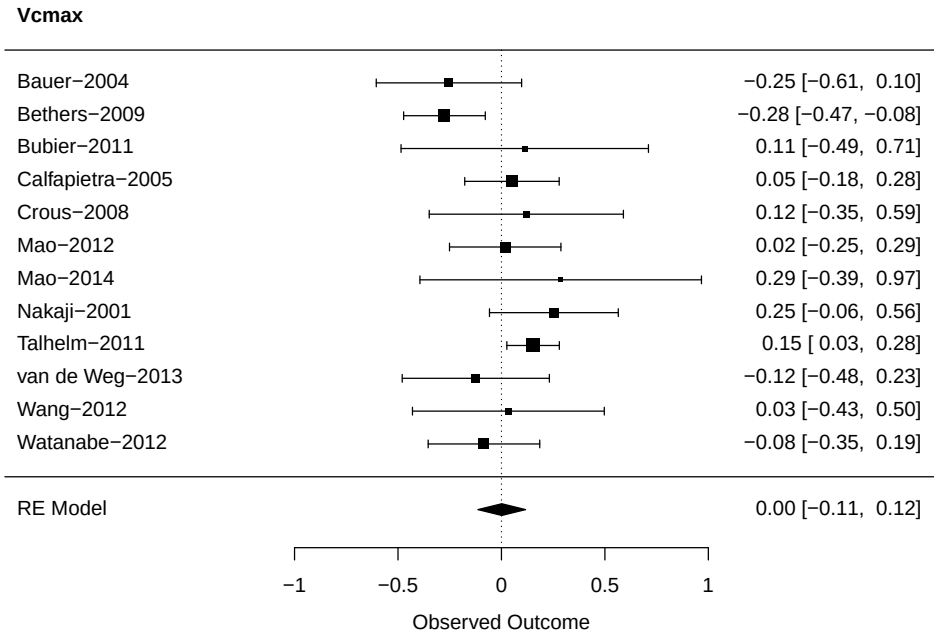

Figure 19: Response of V_{cmax} to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

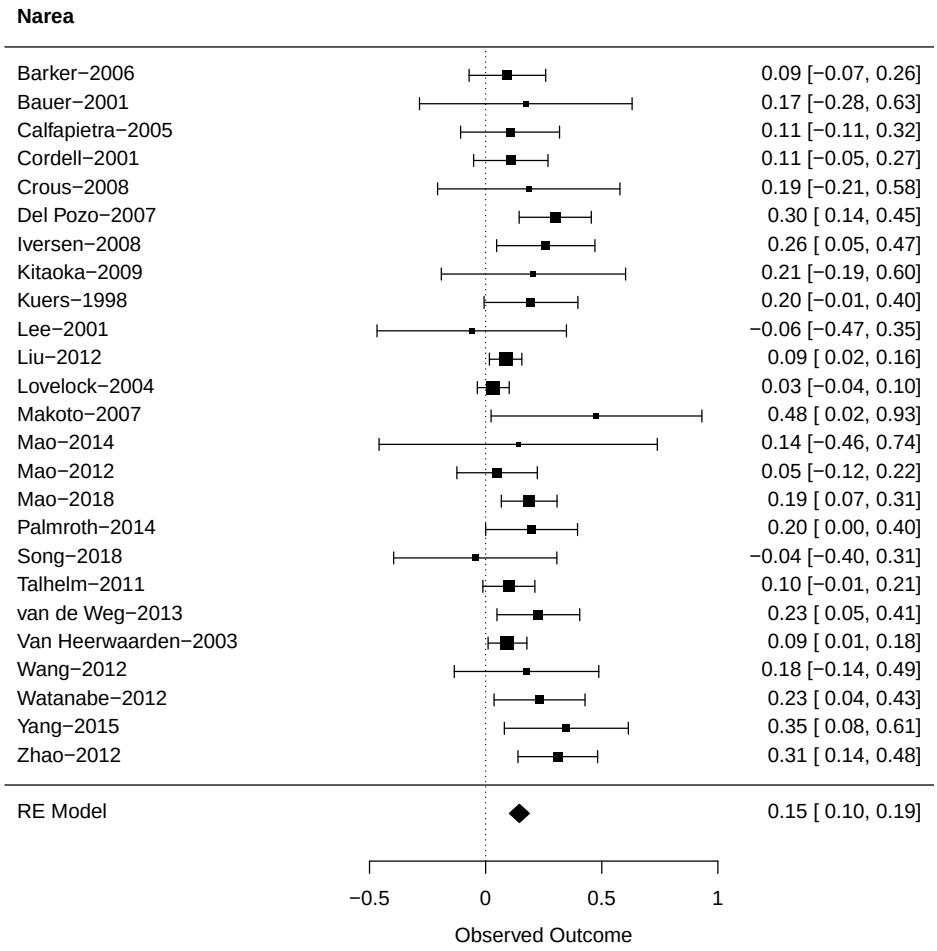

Figure 20: Response of N_{area} (Narea) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

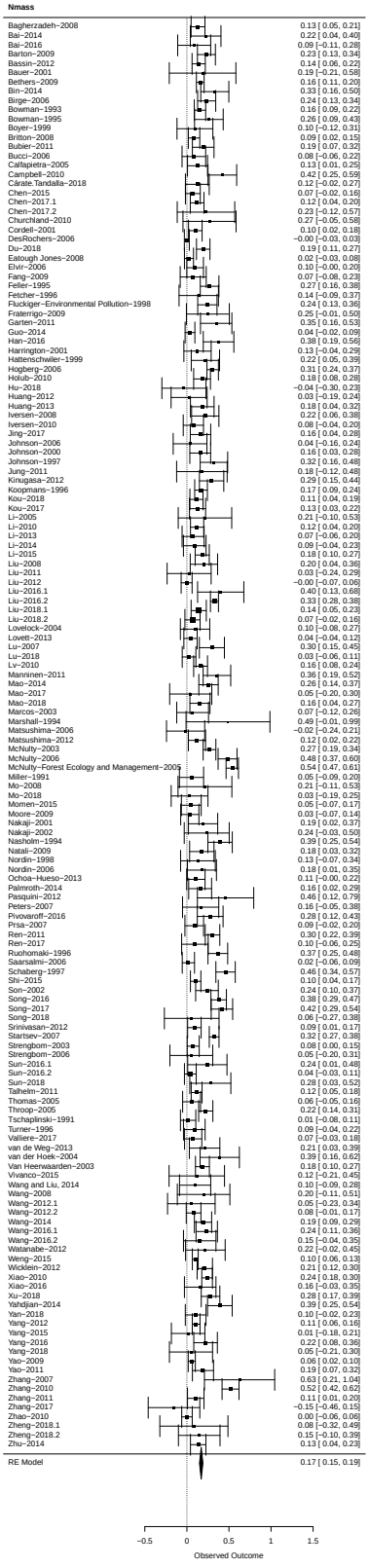

Figure 21: Response of N_{mass} (Nmass) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

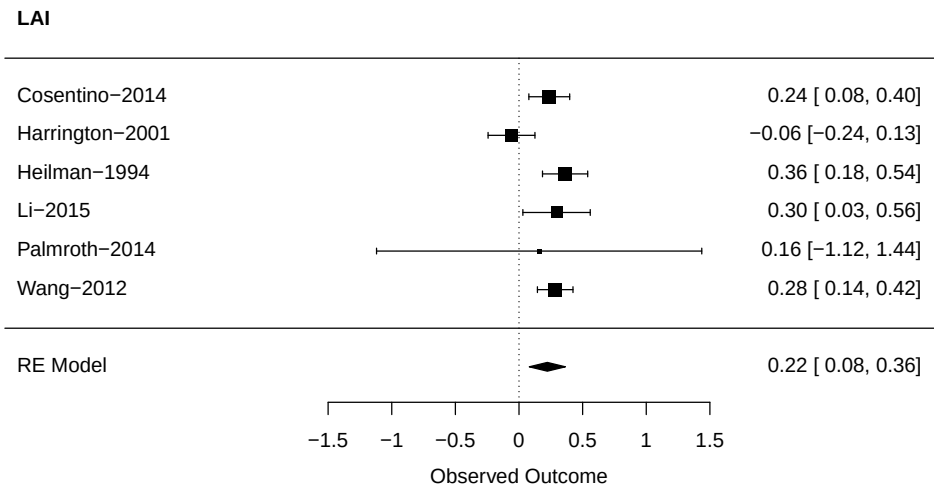

Figure 22: Response of the leaf area index (LAI) to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

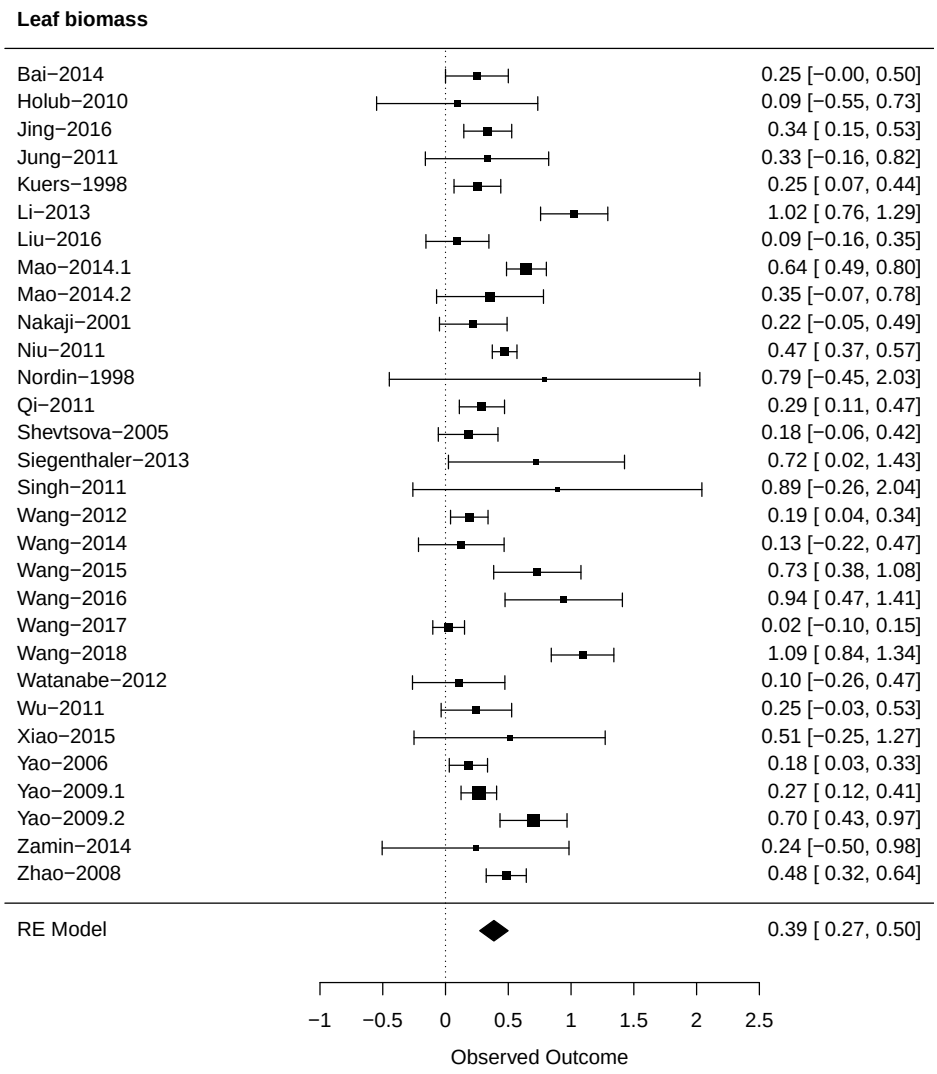

Figure 23: Response of leaf biomass to N-fertilisation in individual experiments and meta-analytic mean across experiments. Plot created with `forest` from the {metafor} R package Viechtbauer (2010).

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