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Supplementary Information for

Plant biodiversity and the regeneration of soil fertility

George N. Furey[1] and David Tilman[2]

Email: furey034@umn.edu[1] ; tilman@umn.edu[2]

This PDF file includes:

1. **Supplemental Figures:** Figures S1 to S11
2. **Supplemental Tables:** Tables S1 to S7
3. **Supplemental Text:** Supplemental discussion of empirical tradeoff surface shown in Fig. 4.
4. **Supplemental Methods:** Estimation of area density quantities of soil nutrients using equivalent soil mass method
5. **Supplemental Metadata:** Metadata for data sets
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    g. Dataset_S7
6. **Other supplementary materials for this manuscript include the following:**
    a. Datasets S1 to S7

1. Supplemental Figures:

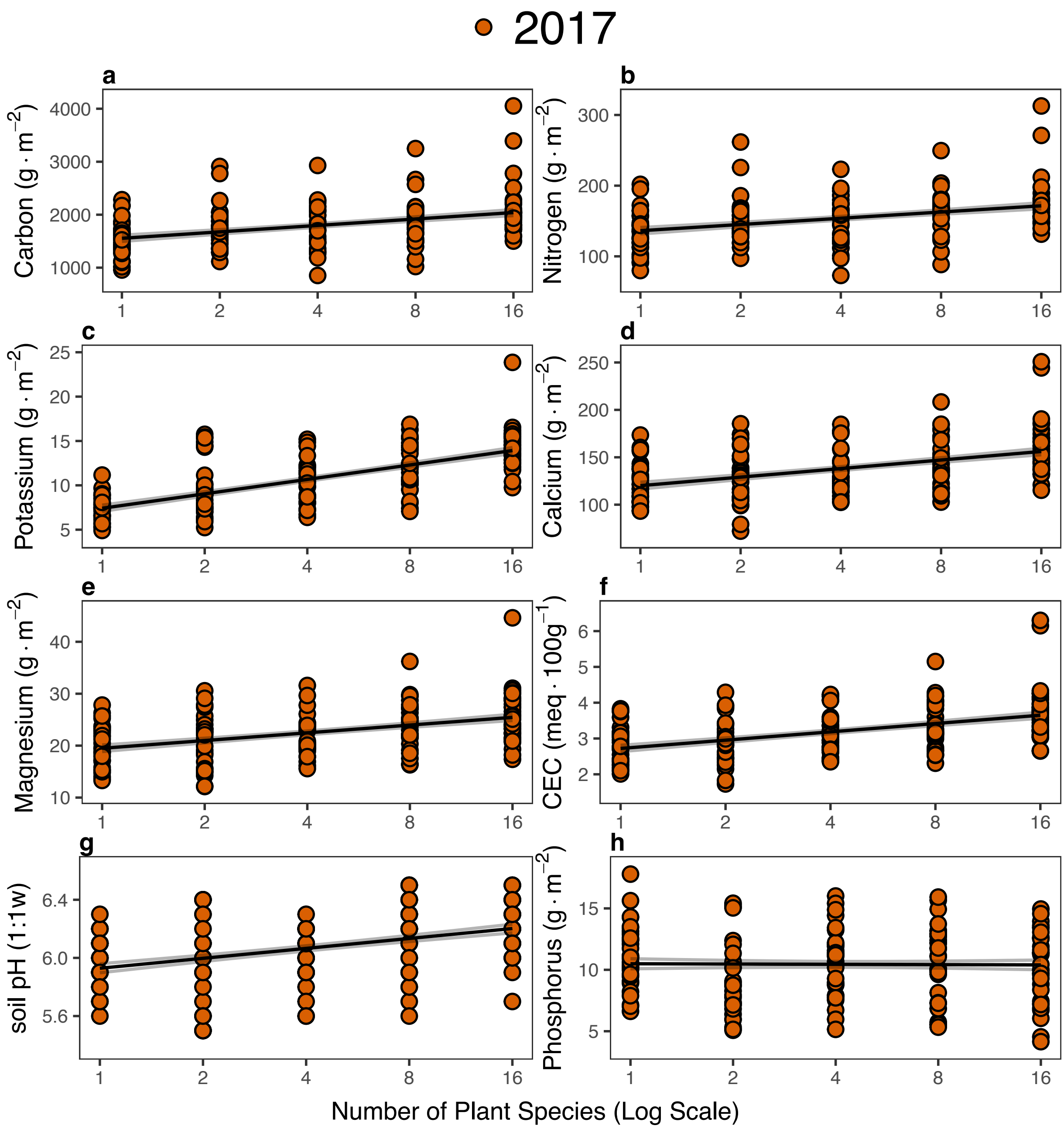


Figure S1: Soil chemistry (area density g m^{-2}) of each plot vs. plant diversity in 2017, the 23rd year of the experiment. Mean ± 1 S.E. of soil chemistry (0-20 cm depth; 2017 in orange (circle)) of **a** total carbon, **b** total nitrogen, **c** exchangeable potassium, **d** exchangeable calcium, **e** exchangeable magnesium, **f** CEC is cation exchange capacity, **g** soil pH and **h** extractable Bray phosphorus versus number of planted species (1, 2, 4, 8, or 16). Lines are linear regressions ± 1 S.E. (n = 154 plots).

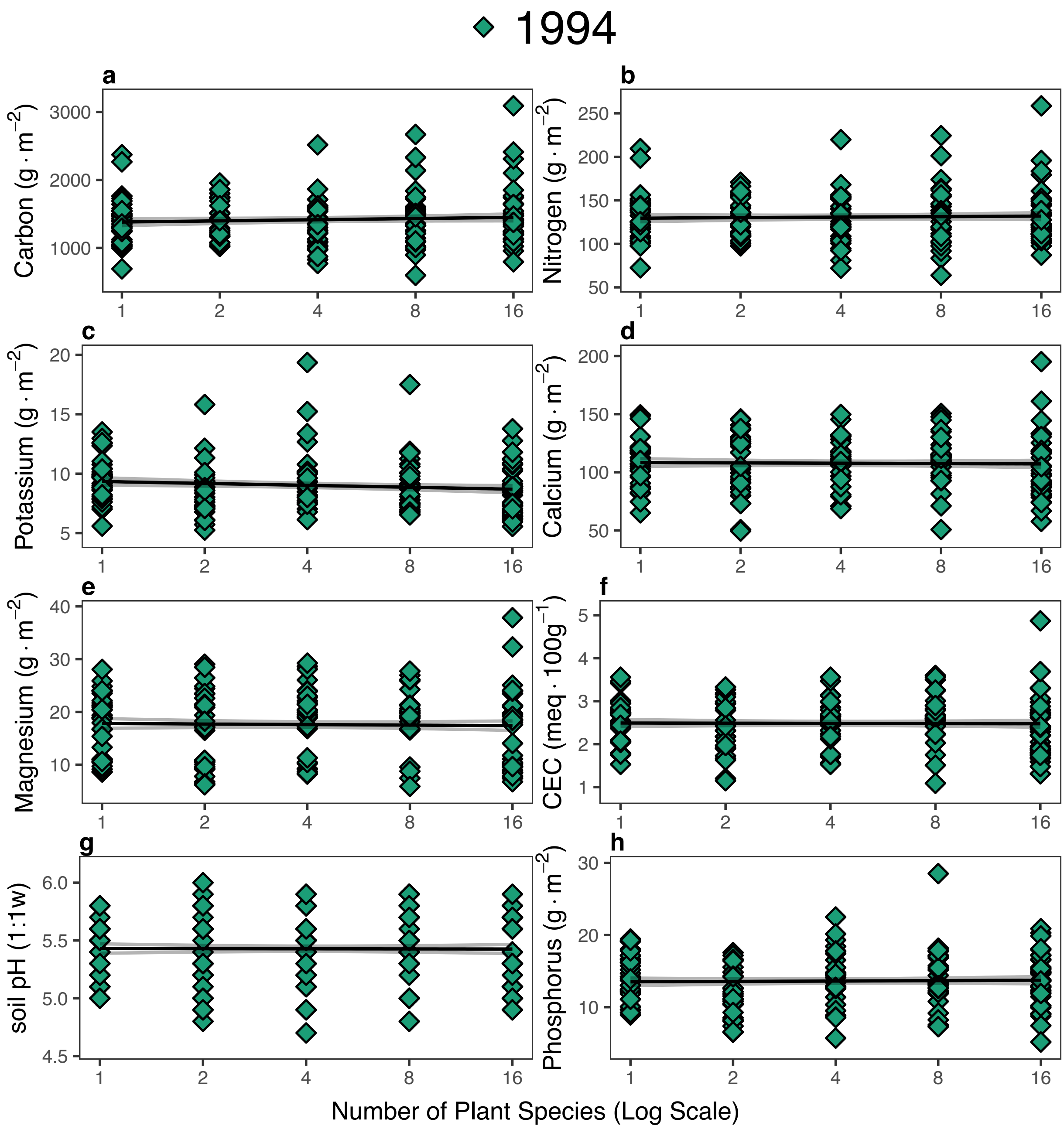


Figure S2: Soil chemistry (area density g m^{-2}) of each plot vs. plant diversity before planting in 1994. Mean ± 1 S.E. of soil chemistry (0-20 cm depth; 2017 in orange (circle)) of **a** total carbon, **b** total nitrogen, **c** exchangeable potassium, **d** exchangeable calcium, **e** exchangeable magnesium, **f** CEC is cation exchange capacity, **g** soil pH and **h** extractable Bray phosphorus versus number of planted species (1, 2, 4, 8, or 16). Lines are linear regressions ± 1 S.E. (n = 154 plots).

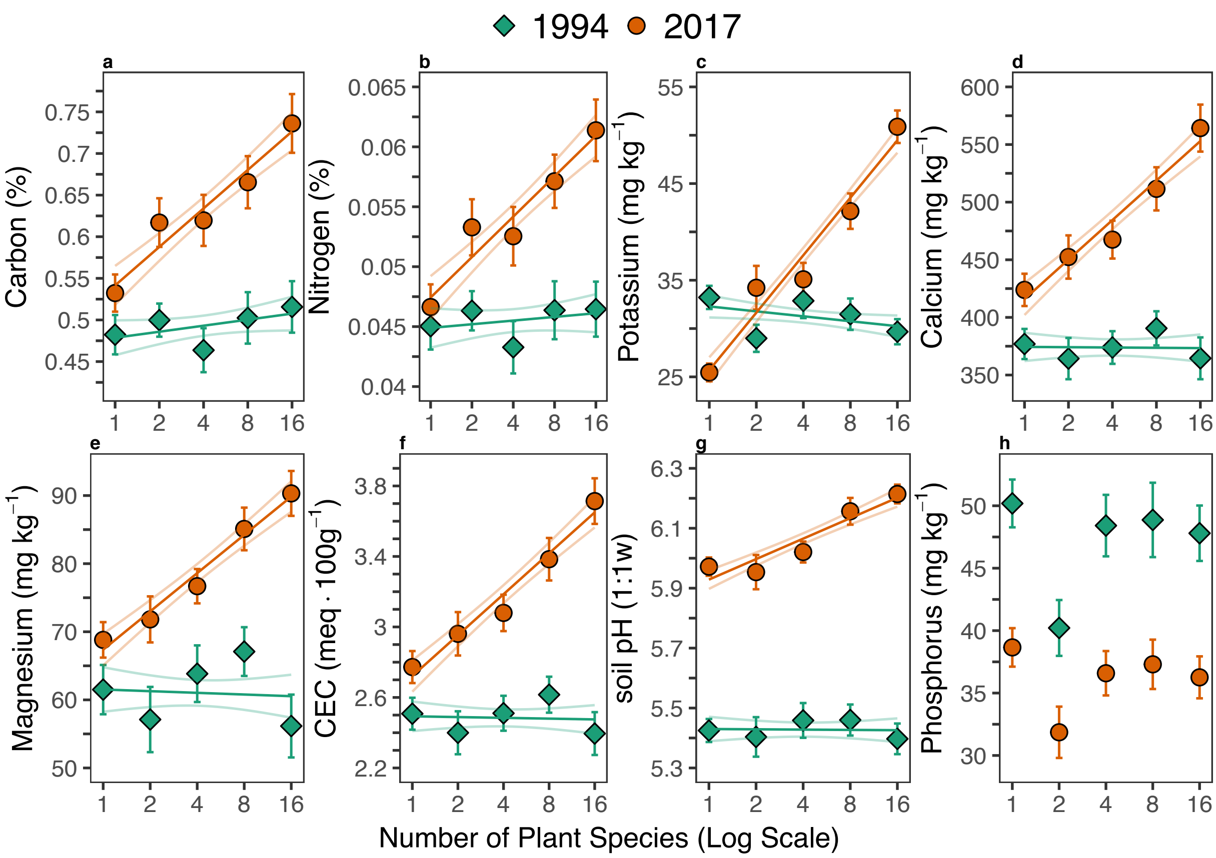


Figure S3: Mean soil chemistry (concentration) vs. plant diversity. Mean ± 1 S.E. of soil chemistry (0-20 cm depth; before planting in 1994 in green (diamond) and in 2017 in orange (circle) of **a** total carbon, **b** total nitrogen, **c** exchangeable potassium, **d** exchangeable calcium, **e** exchangeable magnesium, **f** CEC is cation exchange capacity **g** soil pH and **h** extractable bray phosphorus versus number of planted species (1, 2, 4, 8, or 16; log scale). Lines are linear regressions ± 1 S.E. (n = 154 plots).

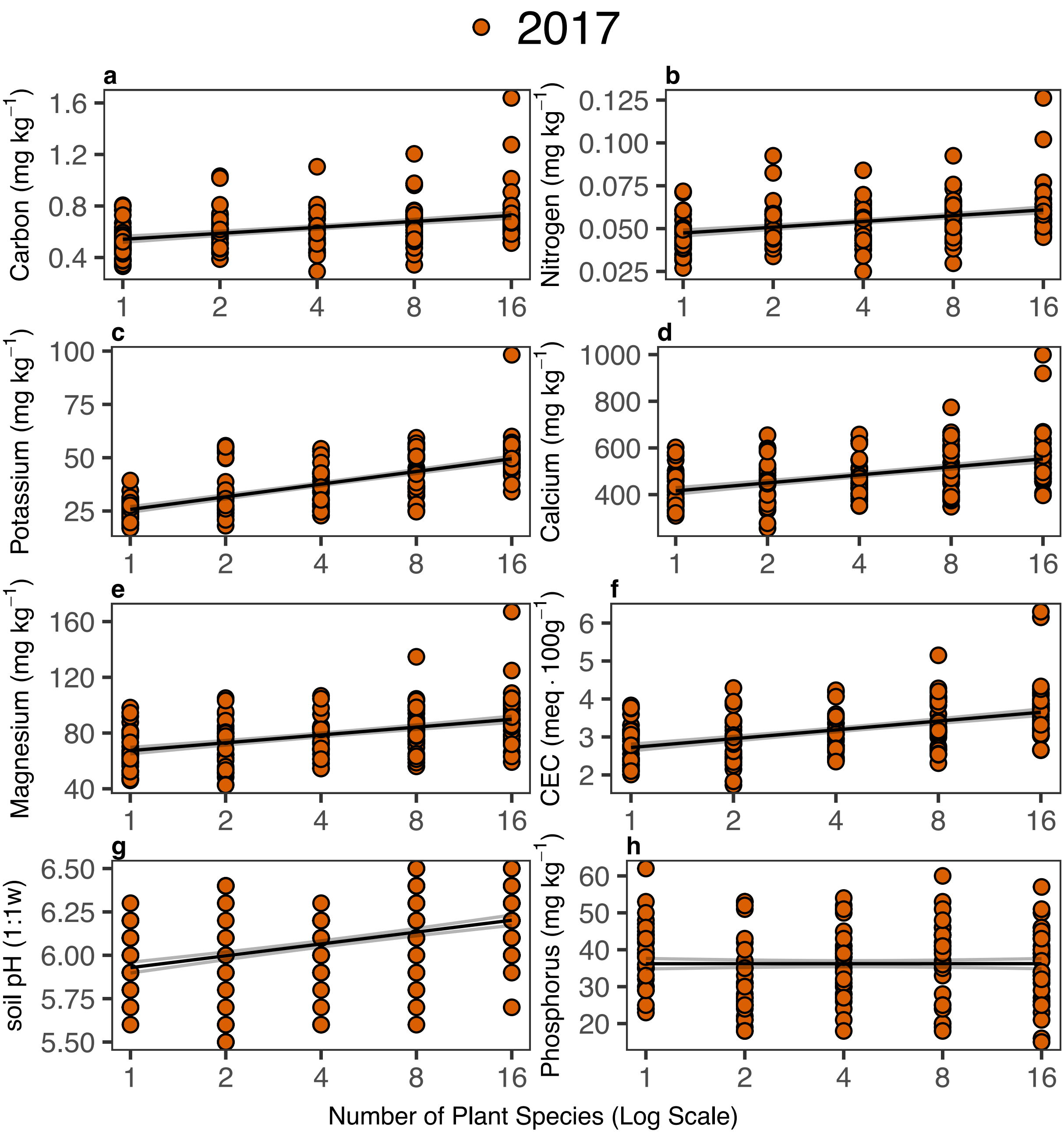


Figure S4: Soil chemistry (concentration) of each plot vs. plant diversity in 2017, the 23rd year of the experiment. Mean ± 1 S.E. of soil chemistry (0-20 cm depth; 2017 in orange (circle)) of **a** total carbon, **b** total nitrogen, **c** exchangeable potassium, **d** exchangeable calcium, **e** exchangeable magnesium, **f** CEC is cation exchange capacity, **g** soil pH and **h** extractable bray phosphorus versus number of planted species (1, 2, 4, 8, or 16). Lines are linear regressions ± 1 S.E. (n = 154 plots).

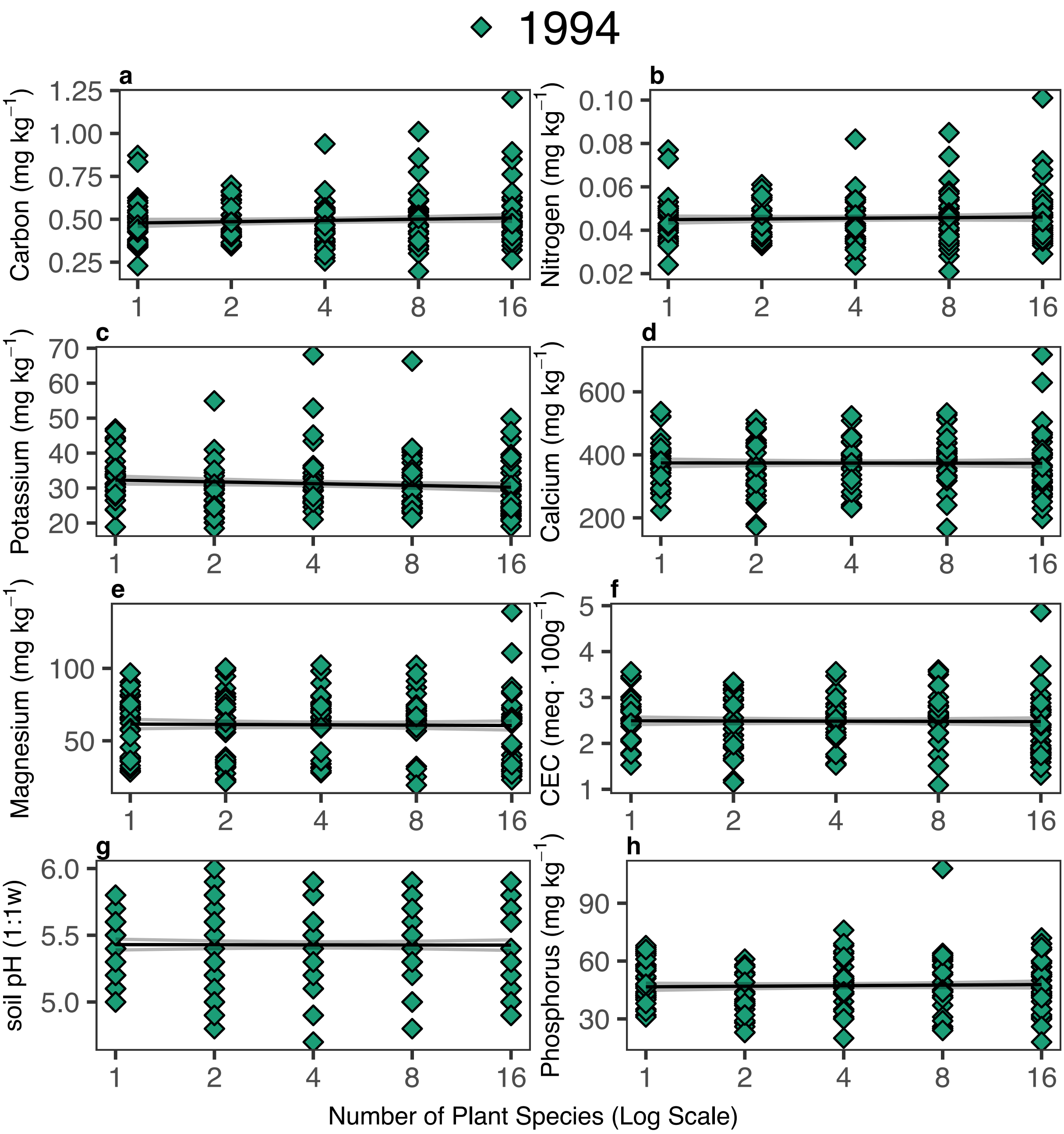


Figure S5: Soil chemistry (concentration) of each plot vs. plant diversity before planting in 1994. Mean ± 1 S.E. of soil chemistry (0-20 cm depth; 2017 in orange (circle)) of **a** total carbon, **b** total nitrogen, **c** exchangeable potassium, **d** exchangeable calcium, **e** exchangeable magnesium, **f** CEC is cation exchange capacity, **g** soil pH and **h** extractable bray phosphorus versus number of planted species (1, 2, 4, 8, or 16). Lines are linear regressions ± 1 S.E. (n = 154 plots).

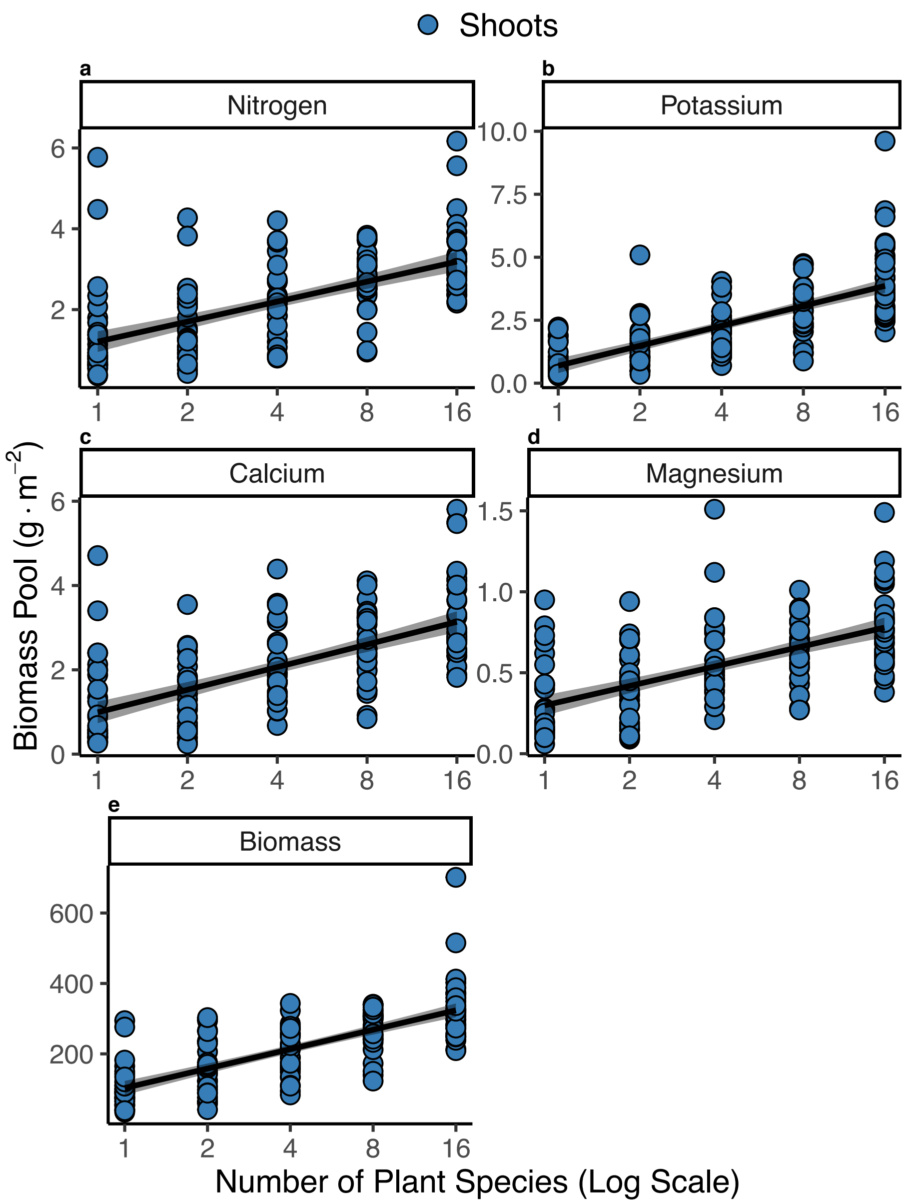


Figure S6: **a-d** Tissue nutrient content in aboveground biomass of each plot (concentration of element * biomass g m^{-2}) vs. plant diversity in 2017. Nutrient content of **a** nitrogen, **b** potassium, **c** calcium and **d** magnesium contained in aboveground plant biomass of each plot (blue; circle), showing the total mass of each element in biomass measured in 2017 (g m^{-2}). **e** Total aboveground dry plant biomass in each plot (g m^{-2}) versus plant diversity. Regression lines show dependence of each variable on the natural log of the number of species ± 1 S.E. (n = 154).

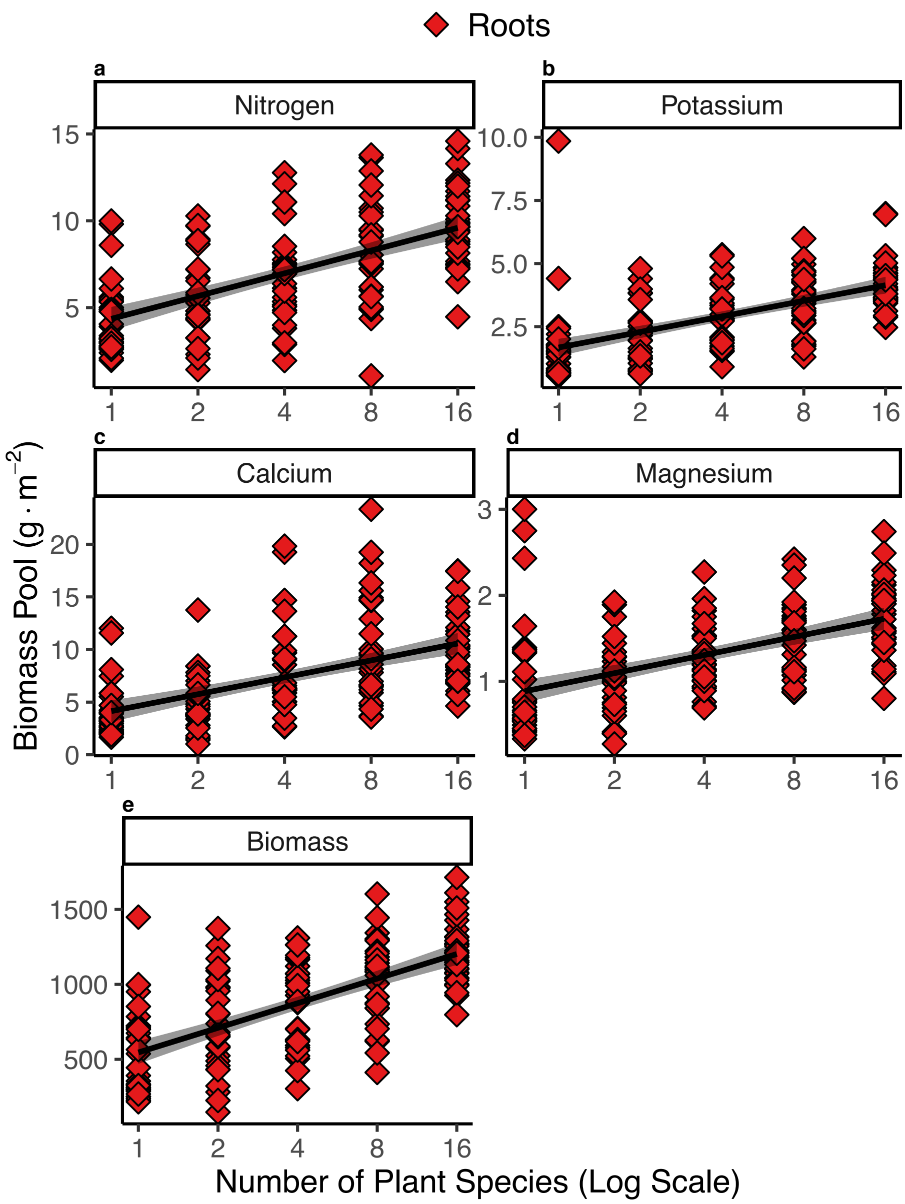


Figure S7: **a-d** Tissue nutrient content in belowground biomass of each plot (concentration of element * biomass g m^{-2}) vs. plant diversity in 2017. Nutrient content of **a** nitrogen, **b** potassium, **c** calcium and **d** magnesium contained in belowground plant biomass of each plot (red; diamond), showing the total mass of each element in biomass (g m^{-2}). **e** Total belowground dry plant biomass in each plot (g m^{-2}) versus plant diversity. Regression lines show dependence of each variable on the natural log of the number of species ± 1 S.E. (n = 154).

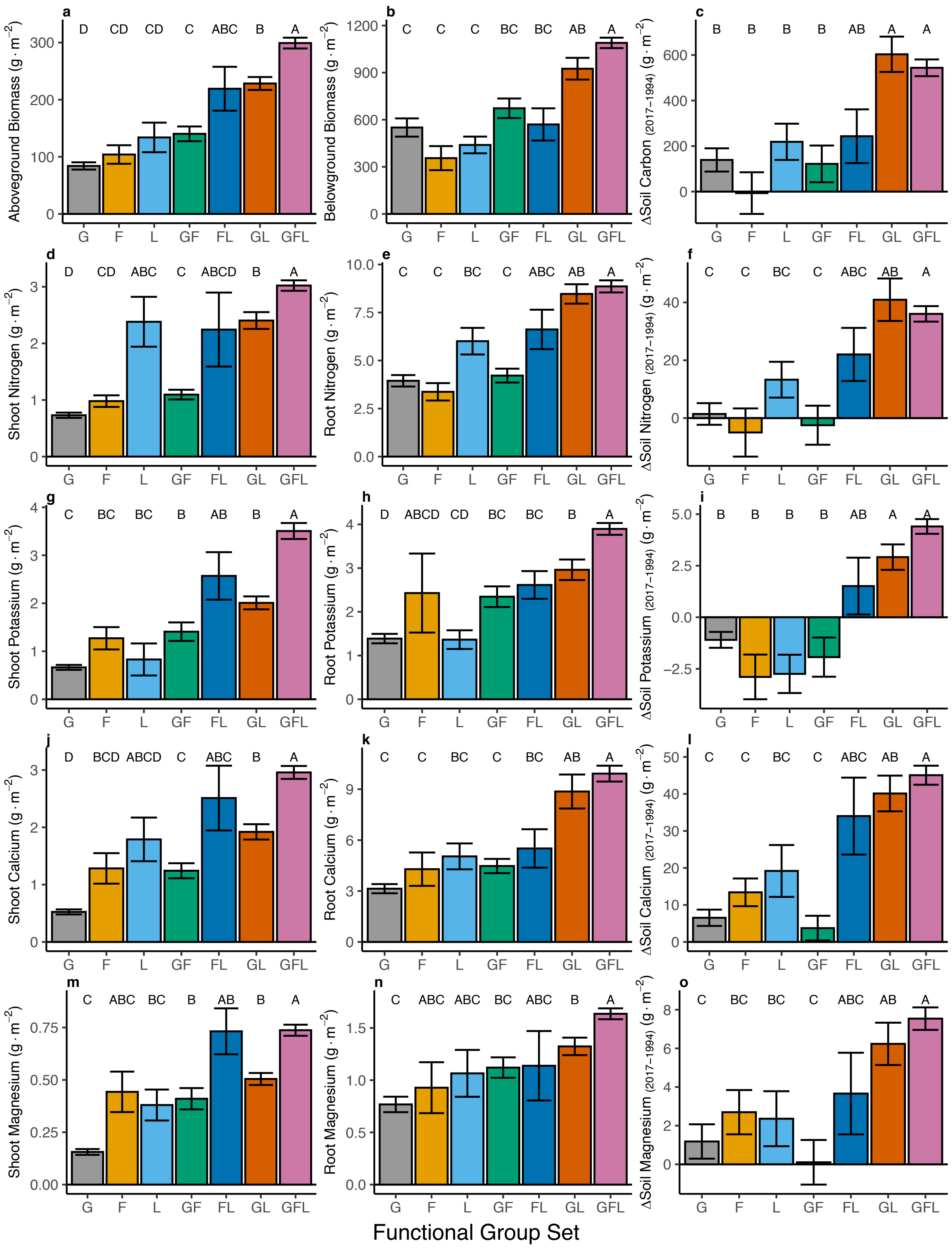


Figure S8: Biomass, nutrient pools and changes in soil nutrient pools from 1994 to 2017 by functional group composition. These panels display the mean ± 1 S.E. for each functional group composition for aboveground and belowground biomass (2017, g m^{-2}; roots 0-30 cm), the quantity of nitrogen, potassium, calcium, and magnesium in those plant tissues (2017, g m^{-2}), and the change in soil carbon, nitrogen, potassium, calcium and magnesium (g m^{-2}, 0-20 cm, 2017 - 1994). **a** aboveground biomass**, b** belowground biomass (0-30 cm), **c** change in soil carbon, **d** quantity of nitrogen in aboveground biomass, **e** quantity of nitrogen in belowground biomass, **f** change in soil nitrogen, **g** quantity of potassium in aboveground biomass, **h** quantity of potassium in root biomass, **i** change in soil potassium, **j** quantity of calcium in aboveground biomass, **k** quantity of calcium in belowground biomass, **l** change in soil calcium, **m** quantity of magnesium in aboveground biomass, **n** quantity of magnesium in belowground biomass, **o** change in soil magnesium. Functional group compositions: G = grasses only, n = 22; F = forb only, n =10; L = legumes only, n = 11; FL = at least 1 forb and 1 legume, n = 5; GL = at least 1 grass and 1 legume, n = 23; GF = at least 1 grass and 1 forb, n = 14; GFL = at least 1 grass, 1 legume and 1 forb, n = 69. Letters indicate if means differ ($P<0.05$) following a Tukey correction.

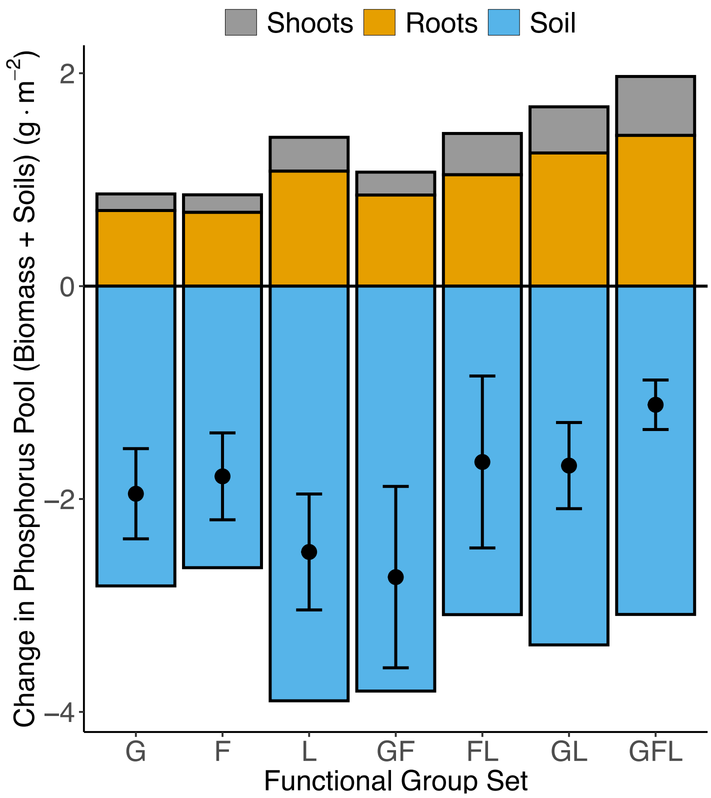


Figure S9: Change in ecosystem nutrient pools for each functional group composition for phosphorus. Pools defined as change from 1994 to 2017 in soil levels (0-20 cm depth increment) plus amounts in aboveground biomass and in roots (0-30 cm) in 2017; sum expressed as g of nutrient m^{-2}. Each point shows the mean ± 1 SE. Bars show the relative value for phosphorus in aboveground biomass (grey), phosphorus in belowground biomass (yellow) and soil (blue). Functional group compositions: G = grasses only n = 22; F = forb only n =10; L = legumes only n = 11; FL = at least 1 forb and 1 legume n= 5; GL = at least 1 grass and 1 legume n = 23; GF = at least 1 grass and 1 forb n = 14; GFL = at least 1 grass, 1 legume and 1 forb n = 69. Means did not differ (all $P > 0.05$).

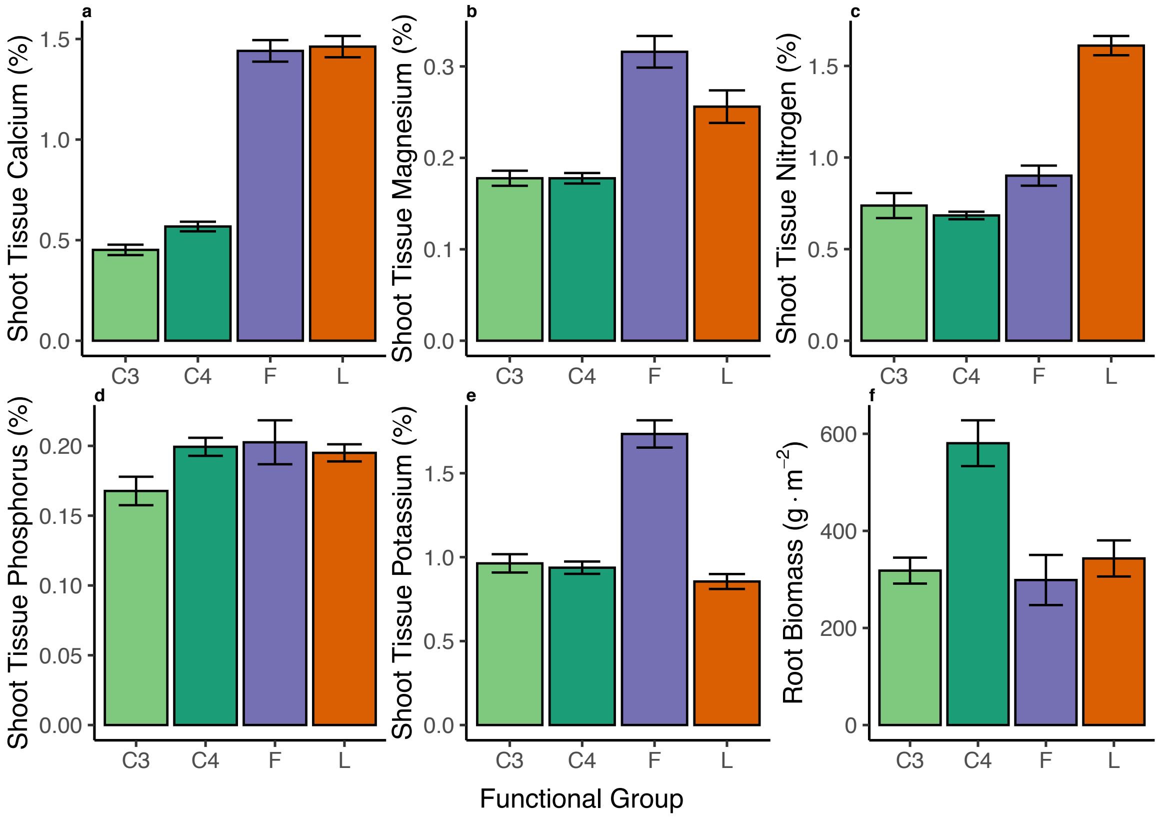


Figure S10: Tissue trait values and root mass by functional group composition. Each bar represents the mean ± 1 SE of each trait for each functional group type. Functional group composition is defined as C4 grass (4 species), C3 grass (2 species), forb (5 species) and legume (4 species) (See Table S7). Shoot chemistry represents the whole plant percentage of each element from samples taken from monocultures and 16-species plots (C3 n = 13; C4 n = 30; forb n = 35; legume n = 30). Root biomass represents the measured values from monoculture plots to a depth of 30 cm (C3 n = 3; C4 n = 10; forb n = 9; legume n = 10).

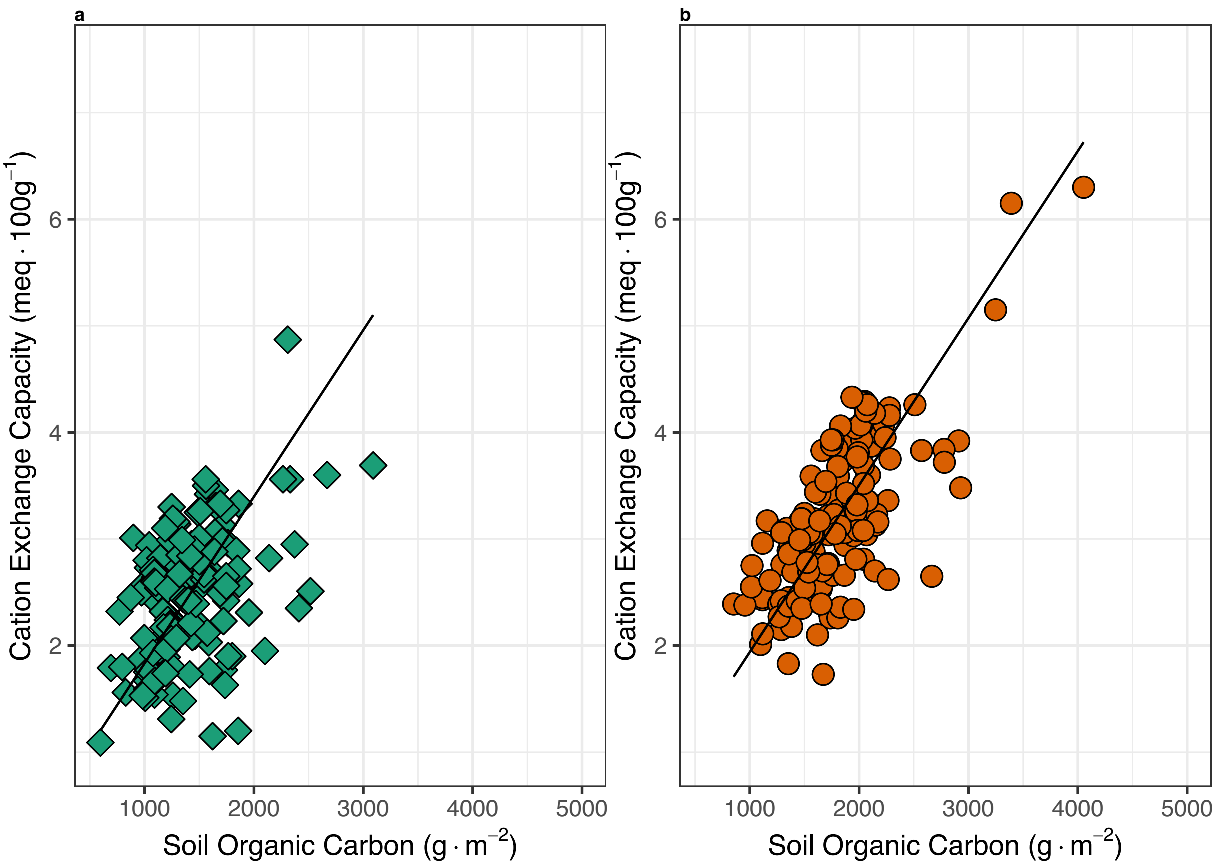


Figure S11: Bivariate relationship between soil organic carbon and soil cation exchange capacity. Baseline values from 1994 **a** are shown as green diamonds and values from 2017 **b** are shown as orange circles (n=154). The black line represents a fit from a major axis regression (1994: R^2=0.20, p<0.001, 2017: R^2=0.52 p<0.001)

2. Supplemental Tables:

Table S1: Soil characteristics measured in 1994 and classification of relative levels based on guidelines of the University of Minnesota Agricultural Extension Service

Nutrient	Test	Value	Relative Levels
Organic matter	Loss on Ignition (400 C)	1.04%	Very Low
Total nitrogen	Combustion	0.046%	Very Low
Available phosphorus	Bray-1 P	47 (mg/kg)	Very High
Available potassium	Ammonium Acetate pH 7	31 (mg/kg)	Very Low

Table S2: Linear regressions testing the dependence of each soil variable (area density g m^{-2}; except for CEC and pH) on the natural log of the number of planted species. A separate regression is shown for each variable in 1994 (pre-treatment) and in 2017 (n=154). Note that all 1994 regressions P values have P>0.25, and all 2017 regressions except for phosphorus have P<0.0001.

Soil Variable	Year	F-Statistic [1,152]	R^2	P-value
Calcium	1994	0.051	0.00	0.82111
Carbon	1994	0.646	0.00	0.42268
CEC	1994	0.017	0.00	0.89523
Magnesium	1994	0.079	0.00	0.77967
Nitrogen	1994	0.126	0.00	0.72318
pH	1994	0.004	0.00	0.95127
Phosphorus	1994	0.077	0.00	0.78137
Potassium	1994	1.666	0.01	0.19873
Calcium	2017	40.496	0.21	<0.0001
Carbon	2017	26.690	0.15	<0.0001
CEC	2017	43.372	0.22	<0.0001
Magnesium	2017	35.440	0.19	<0.0001
Nitrogen	2017	23.999	0.14	<0.0001
pH	2017	30.938	0.17	<0.0001
Phosphorus	2017	0.020	0.00	0.88636
Potassium	2017	136.373	0.47	<0.0001

Table S3: Linear regressions testing the dependence of each soil variable (concentration mg kg^{-1}) on the natural log of the number of plant species. A separate regression is shown for each variable in 1994 (pre-treatment) and in 2017 (n=154). Note that all 1994 regressions P values have *P*>0.25, and all 2017 regressions except for phosphorus have *P*<0.0001.

Soil Variable	Year	F-Statistic [1,152]	R^2	P-value
Calcium	1994	0.003	0.00	0.95768
Carbon	1994	0.760	0.00	0.38484
Magnesium	1994	0.036	0.00	0.85036
Nitrogen	1994	0.220	0.00	0.64002
Phosphorus	1994	0.156	0.00	0.69372
Potassium	1994	1.266	0.01	0.26229
Calcium	2017	38.836	0.20	<0.0001
Carbon	2017	24.691	0.14	<0.0001
Magnesium	2017	37.007	0.20	<0.0001
Nitrogen	2017	22.574	0.13	<0.0001
Phosphorus	2017	0.000	0.00	0.99463
Potassium	2017	126.390	0.45	<0.0001

Table S4: Linear regressions testing the dependence on $\log_e$(number of plant species) of the 2017 % change relative to the 2017 monoculture mean for aboveground (shoots) and belowground (roots) biomass (0-30 cm) and the quantity of nitrogen, calcium, magnesium, and potassium within those tissues. See Figure 2 for graphs of regressions for all variables except biomass. A separate regression is shown for each variable (n=154).

Nutrient	Shoots|Roots	F-Statistic [1,152]	R^2	P-value
Biomass	Shoots	185.605	0.55	<0.0001
Calcium	Shoots	107.760	0.41	<0.0001
Magnesium	Shoots	89.289	0.37	<0.0001
Nitrogen	Shoots	92.032	0.38	<0.0001
Potassium	Shoots	180.298	0.54	<0.0001
Biomass	Roots	114.936	0.43	<0.0001
Calcium	Roots	60.450	0.28	<0.0001
Magnesium	Roots	61.385	0.29	<0.0001
Nitrogen	Roots	90.581	0.37	<0.0001
Potassium	Roots	79.612	0.34	<0.0001

Table S5: Ecosystem nutrient pools by functional group composition. Pools defined as change from 1994 to 2017 in soil levels (0-20 cm depth increment) plus amounts in aboveground biomass and in roots (0-30 cm) in 2017; sum expressed as g of nutrient m^{-2}. Functional group compositions: G = grasses only n = 22; F = forb only n =10; L = legumes only n = 11; FL = at least 1 forb and 1 legume n = 5; GL = at least 1 grass and 1 legume n = 23; GF = at least 1 grass and 1 forb n = 14; GFL = at least 1 grass, 1 legume and 1 forb n = 69. Group letters indicate if means differ (P<0.05) following a Tukey correction.

Nutrient	Functional Group	Mean	SE	degrees of freedom	Lower confidence interval (95%)	Upper confidence interval (95%)	Group
Calcium	G	10.19	2.19	21	5.64	14.74	C
Calcium	F	18.98	4.24	9	9.39	28.57	C
Calcium	L	26.02	6.53	12	11.83	40.20	BC
Calcium	GF	9.44	3.63	13	1.61	17.28	C
Calcium	FL	42.02	9.69	12	20.98	63.06	ABC
Calcium	GL	50.90	4.97	22	40.57	61.22	AB
Calcium	GFL	57.93	2.66	65	52.61	63.24	A
Magnesium	G	2.11	0.89	21	0.24	3.97	C
Magnesium	F	4.07	1.21	9	1.32	6.82	BC
Magnesium	L	3.80	1.38	9	0.69	6.91	BC
Magnesium	GF	1.64	1.16	14	-0.85	4.12	C
Magnesium	FL	5.53	2.04	9	0.92	10.14	ABC
Magnesium	GL	8.06	1.11	22	5.76	10.36	AB
Magnesium	GFL	9.91	0.59	68	8.73	11.09	A
Nitrogen	G	6.10	3.77	21	-1.75	13.95	B
Nitrogen	F	-0.63	8.44	9	-19.76	18.49	B
Nitrogen	L	21.67	6.01	15	8.86	34.48	B
Nitrogen	GF	2.85	6.77	13	-11.78	17.47	B
Nitrogen	FL	30.88	8.92	15	11.88	49.87	AB
Nitrogen	GL	51.80	7.38	22	36.50	67.11	A
Nitrogen	GFL	47.93	2.72	68	42.50	53.35	A
Phosphorus	G	-1.95	0.42	21	-2.83	-1.07	A
Phosphorus	F	-1.79	0.41	9	-2.71	-0.86	A
Phosphorus	L	-2.50	0.54	16	-3.65	-1.34	A
Phosphorus	GF	-2.73	0.85	13	-4.57	-0.89	A
Phosphorus	FL	-1.65	0.81	16	-3.37	0.06	A
Phosphorus	GL	-1.69	0.40	22	-2.52	-0.85	A
Phosphorus	GFL	-1.11	0.23	68	-1.58	-0.65	A
Potassium	G	0.96	0.47	21	-0.03	1.94	C
Potassium	F	0.81	1.65	9	-2.93	4.54	C
Potassium	L	-0.55	1.31	12	-3.40	2.30	C
Potassium	GF	1.82	0.87	13	-0.06	3.70	C
Potassium	FL	6.70	1.94	12	2.47	10.92	ABC
Potassium	GL	7.89	0.85	21	6.11	9.66	B
Potassium	GFL	11.80	0.52	66	10.76	12.85	A

Table S6: Summary table displaying model-averaged coefficients for linear regressions testing the dependency of the sum of aboveground plus belowground biomass (Root 0-30 cm) (2015 and 2017) on the natural log of the number of planted species and on soil variables (total N, total C, Bray-P, exchangeable Ca, Mg, K and soil pH). The conditional average is presented for each coefficient.

Nutrient	Coefficient	Std. Error	Adjusted SE	z value	Pr(>|z|)
K	51.254	8.790	8.860	5.785	<0.001
logNumSp	156.232	25.602	25.810	6.053	<0.001
C	0.227	0.050	0.050	4.536	<0.001
N	2.871	0.667	0.672	4.273	<0.001
P	-7.980	6.400	6.453	1.237	0.216
Mg	-4.929	4.612	4.649	1.060	0.289
(Intercept)	-65.922	91.138	91.759	0.718	0.472

Table S7: List of the fifteen herbaceous perennial plant species that persisted in monocultures and mixtures. For each species, its functional group and plant family is shown. Each species is represented by one point in Figure 4.

Species	Functional Group	Family
Achillea millefolium	Forb	Asteraceae
Amorpha canescens	Legume	Fabaceae
Andropogon gerardii	C4 Grass	Poaceae
Asclepias tuberosa	Forb	Apocynaceae
Koeleria macrantha	C3 Grass	Poaceae
Lespedeza capitata	Legume	Fabaceae
Liatris aspera	Forb	Asteraceae
Lupinus perennis	Legume	Fabaceae
Monarda fistulosa	Forb	Lamiaceae
Panicum virgatum	C4 Grass	Poaceae
Dalea purpureum	Legume	Fabaceae
Poa pratensis	C3 Grass	Poaceae
Schizachyrium scoparium	C4 Grass	Poaceae
Solidago rigida	Forb	Asteraceae
Sorghastrum nutans	C4 Grass	Poaceae

3. Supplemental Text: Supplemental discussion of empirical tradeoff surface shown in Fig. 4.

We conducted additional analyses to test the robustness of the tradeoff surface shown in Fig 4. Because of poor establishment or poor survival in monoculture or the presence of a second species in a monoculture, there were difficulties in accurately determining root mass for *Poa pratensis* and *Monarda fistulosa.* We therefore tested two subsets of the available data and found that all had a fitted planar surface defining tradeoffs just like those of Fig. 4. Removing monoculture data for *P. pratensis,* which survived in only one monoculture and was rare in it, improved the fit ($F_{2,11} = 11.3$, $R^2 = 0.67$, $p = 0.0021$). Removing both *M. fistulosa* and *P. pratensis* gave a similar fit ($F_{2,10} = 10.28$, $R^2 = 0.67$, $p = 0.0038$).

To better estimate aboveground tissue chemistry for each species, Fig. 4 uses the species-specific average of tissue chemistry measurements in monoculture and in five 16-species plots. When instead we use only species-specific chemistry measured values from monoculture plots, the resulting tradeoff surface was similar, with $F_{2,30} = 8.26$, $R^2 = 0.36$, $p = 0.00139$. Removing *M. fistulosa* and *P. pratensis* increased the fit to $F_{2,27} = 13.87$, $R^2 = 0.51$, $p < 0.0001$.

4. **Supplemental Methods:** Estimation of area density quantities of soil nutrients using equivalent soil mass method

Formula to calculate the amount in $\frac{\text{g}}{\text{m}^2}$ of a nutrient in a soil core of length T.

where:
x = element in soil

C = concentration of element x $(\frac{\text{mg}_x}{\text{Kg}_{\text{soil}}})$

ρ = bulk density $(\frac{\text{g}_{\text{soil}}}{\text{cm}^3})$

T = depth or thickness of soil layer (cm)

Area density quantity of nutrient $x_{\frac{\text{g}}{\text{m}^2}} = C_{\frac{\text{mg}_x}{\text{Kg}_{\text{soil}}}} * \frac{1_{g_x}}{1000_{\text{mg}_x}} * \rho_{\frac{\text{g}_{\text{soil}}}{\text{cm}^3}} * \frac{1_{\text{Kg}_{\text{soil}}}}{1000_{\text{g}_{\text{soil}}}} * T_{\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}$

Formula to determine the mass of soil per m^{-2} of surface area in a block of soil with a thickness of T. Reference (1).

Where:

M_{soil} is the mass of soil

$$M_{\text{soil}} = \rho_{\frac{\text{g}_{\text{soil}}}{\text{cm}^3}} * T_{\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}$$

$$M_{\text{soil}} = \frac{\text{g}}{\text{m}^2}$$

If a soil is sampled a second time and its bulk density has changed, we must calculate the added or subtracted thickness required to sample the same dry mass of soil.

Formula to calculate added or subtracted thickness:

T_{add} is the amount of extra thickness to add from deeper depths for equivalent mass. If T_{add} is negative, the soil became more dense and it is the amount to subtract to give equivalent mass, called T_{subtract} below.

If the soil bulk density decreased through time $_{\text{i.e.}}$ it has expanded and is less dense, then we must add soil mass from the subsoil to give a mass equivalent to the original.

$$T_{\text{add}} = \frac{(M_{(\text{0-20cm}),1994} \frac{\text{g}}{m^2} - M_{(\text{0-20cm}),2017} \frac{\text{g}}{m^2}) * \frac{1_{\text{m}}}{100_{\text{cm}}} * \frac{1_{\text{m}}}{100_{\text{cm}}}}{\rho_{(\text{20-40cm}),2017} \frac{\text{g}}{\text{cm}^3}}$$

$$T_{\text{add}} = \text{cm}$$

T_{add} is the depth of added soil required to keep the total soil mass the same as the original.

If the soil bulk density increased through time $_{\text{i.e.}}$ it has contracted and is now more dense. We must subtract soil mass from the target soil to give equivalent mass.

$$T_{\text{subtract}} = \frac{(M_{(\text{0-20cm}),1994} \frac{\text{g}}{\text{m}^2} - M_{(\text{0-20cm}),2017} \frac{\text{g}}{\text{m}^2}) * \frac{1_{\text{m}}}{100_{\text{cm}}} * \frac{1_{\text{m}}}{100_{\text{cm}}}}{\rho_{(\text{0-20cm}),2017} \frac{\text{g}}{\text{cm}^3}}$$

$$T_{\text{subtract}} = \text{cm}$$

T_{subtract} is the depth of soil removed required to keep the total soil mass the same as the original.

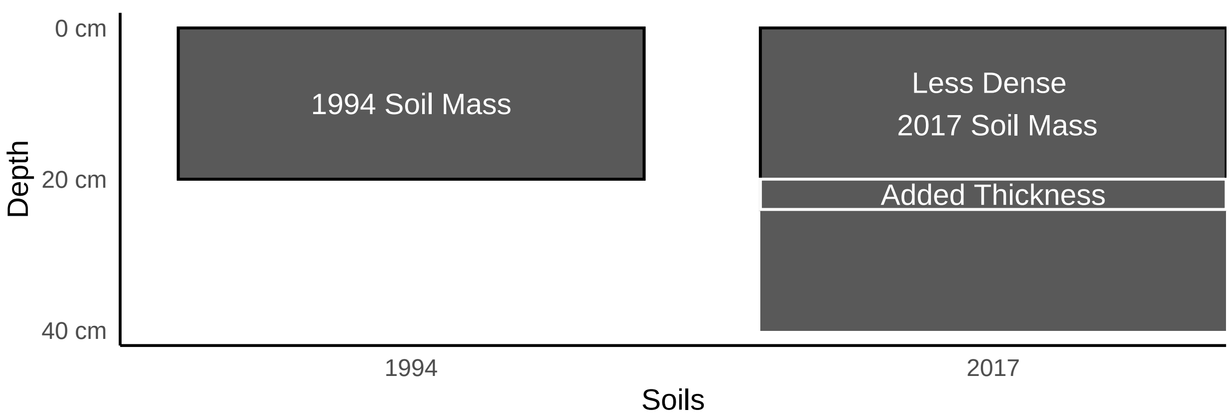
The soil bulk density was estimated in 1994 (0-20 cm) based on a regression of the dependence of soil bulk density in 2018 on % soil C in 2017 (0-20 cm). The regression was used with measured values of % soil C in 1994 (0-20 cm) to estimate soil bulk density in 1994 (0-20 cm). Estimated values in 1994 had a mean of ~ 1.45 $\frac{g}{\text{cm}^3}$ which aligns with 1.4 $\frac{g}{\text{cm}^3}$ from a soil survey of this Nymore series 0-23 cm (2).

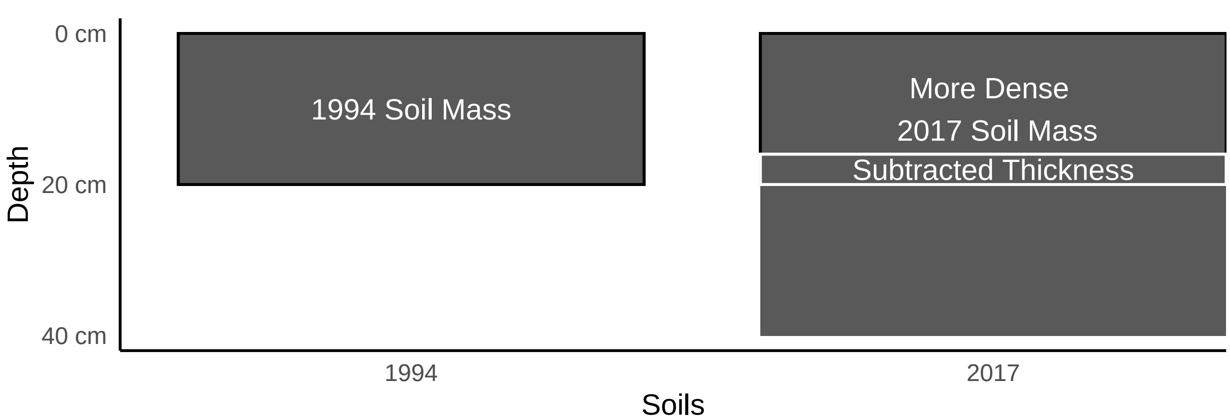
To estimate the area density quantity $\frac{\text{g}}{\text{m}^2}$ of a given soil nutrient (0-20 cm) in 2017 when the soil bulk density has decreased from the value in 1994 (0-20 cm):

$$\text{Area density quantity of nutrient } x_{\frac{\text{g}}{\text{m}^2}} = [\rho_{\frac{\text{g}_\text{soil}(\text{0-20cm})}{\text{cm}^3}} * 20_{\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}] * X_{\frac{\text{g}_x}{\text{g}_\text{soil}}}(\text{0-20cm}) + [\rho_{\frac{\text{g}_\text{soil}(\text{20-40cm})}{\text{cm}^3}} * T_{\text{add}_\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}] * X_{\frac{\text{g}_x}{\text{g}_\text{soil}}}(\text{20-40cm})$$

To estimate the area density quantity $\frac{\text{g}}{\text{m}^2}$ of a given soil nutrient (0-20 cm) in 2017 when the soil bulk density has increased from the value in 1994 (0-20 cm):

$$\text{Area density quantity of nutrient } x_{\frac{\text{g}}{\text{m}^2}} = [\rho_{\frac{\text{g}_\text{soil}(\text{0-20cm})}{\text{cm}^3}} * 20_{\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}] * X_{\frac{\text{g}_x}{\text{g}_\text{soil}}}(\text{0-20cm}) + [\rho_{\frac{g_\text{soil}(\text{0-20cm})}{\text{cm}^3}} * T_{\text{subtract}_\text{cm}} * \frac{100_{\text{cm}}}{1_{\text{m}}} * \frac{100_{\text{cm}}}{1_{\text{m}}}] * X_{\frac{\text{g}_x}{\text{g}_\text{soil}}}(\text{0-20cm})$$





References

1. B. H. Ellert, J. R. Bettany, Calculation of organic matter and nutrients stored in soils under contrasting management regimes. Can. J. Soil. Sci. 75, 529–538 (1995).

2. D. F. Grigal, Soils of the Cedar Creek Natural History Area (Agricultural Experiment Station, University of Minnesota, 1974).

5. Supplemental Metadata: Metadata for datasets S1-S7.

Dataset_S1
Figures: Fig. 1, 3 and Fig 2 derived in Dataset S6
Supplemental Figures: Fig. S1, S2, S6, S7, S8, S9 and S11
Comment: This dataset contains soil and plant area density quantities measured in each plot.

Variable	Metadata
Plot	Experimental plot number
NumSp	Number of planted species
Species	Five letter abbreviation of the name of each planted species in the experiment within each plot. The field represents the first three letters of the genus and the first two letters of species
Fgset	The functional group set of the planted species including a separate field for C3 grasses, C4 grasses, Forbs and Legumes.
Fgset2	The functional group set of the planted species where all grasses are classified as being in the same functional group, G
soil_diffgm2_0.20cm_Calcium_aa	The difference from 1994 to 2017 in exchangeable calcium in a plot, using soil collected from 0-20 cm; expressed as grams of Ca per meter squared
soil_diffgm2_0.20cm_Carbon_ea	The difference from 1994 to 2017 in grams of C per meter squared for total carbon[1] using soil collected from 0-20 cm.
soil_diffgm2_0.20cm_CEC_aa	The difference from 1994 to 2017 in milliequivalents per 100 gram soil of cation exchange capacity for soil collected from 0-20 cm
soil_diffgm2_0.20cm_Magnesium_aa	The difference from 1994 to 2017 in exchangeable magnesium in a plot, using soil collected from 0-20 cm; expressed as grams of Mg per meter squared
soil_diffgm2_0.20cm_Nitrogen_ea	The difference from 1994 to 2017 in grams of N per meter squared for total nitrogen[1] using soil collected from 0-20 cm.
soil_diffgm2_0.20cm_pH_1.1w	The difference from 1994 to 2017 in -log[H+] of dried soil pH 1:1 drysoil:water using soil collected from 0-20 cm
soil_diffgm2_0.20cm_Phosphorus_bray	The difference from 1994 to 2017 in grams of P per meter squared for Bray phosphorus using soil collected from 0-20 cm
soil_diffgm2_0.20cm_Potassium_aa	The difference from 1994 to 2017 in exchangeable potassium in a plot, using with

	soil collected from 0-20 cm; expressed as grams of K per meter squared
gm2_1994_0.20cm_Calcium_aa	The amount of Ca in grams per meter squared in 1994 of exchangeable calcium using soil collected from 0-20 cm
gm2_1994_0.20cm_Carbon_ea	The amount of C in grams per meter squared in 1994 of total carbon using soil collected from 0-20 cm
gm2_1994_0.20cm_CEC_aa	The amount in milliequivalents per 100 gram soil in 1994 of cation exchange capacity using soil collected from 0-20 cm
gm2_1994_0.20cm_Magnesium_aa	The amount of Mg in grams per meter squared in 1994 of exchangeable magnesium using soil collected from 0-20 cm
gm2_1994_0.20cm_Nitrogen_ea	The amount of N in grams per meter squared in 1994 of total nitrogen using soil collected from 0-20 cm
gm2_1994_0.20cm_pH_1.1w	The amount in -log[H+] in 1994 of dried soil pH 1:1 drysoil:water using soil collected from 0-20 cm
gm2_1994_0.20cm_Phosphorus_bray	The amount of P in 1994 in grams per meter squared of Bray phosphorus using soil collected from 0-20 cm
gm2_1994_0.20cm_Potassium_aa	The amount of K in grams per meter squared in 1994 of exchangeable potassium using soil collected from 0-20 cm
gm2_2017_0.20cm_Calcium_aa	The amount of Ca in grams per meter squared in 2017 of exchangeable calcium using soil collected from 0-20 cm
gm2_2017_0.20cm_Carbon_ea	The amount of C in grams per meter squared in 2017 of total carbon[1] using soil collected from 0-20 cm
gm2_2017_0.20cm_CEC_aa	The amount in milliequivalents per 100 gram soil in 2017 of cation exchange capacity using soil collected from 0-20 cm
gm2_2017_0.20cm_Magnesium_aa	The amount of Mg in grams per meter squared in 2017 of exchangeable magnesium using soil collected from 0-20 cm
gm2_2017_0.20cm_Nitrogen_ea	The amount of N in grams per meter squared in 2017 of total nitrogen[1] using soil collected from 0-20 cm
gm2_2017_0.20cm_pH_1.1w	The amount in -log[H+] in 2017 of dried soil pH 1:1 drysoil:water using soil collected from 0-20 cm

gm2_2017_0.20cm_Phosphorus_bray	The amount of P in 2017 in grams per meter squared of Bray phosphorus using soil collected from 0-20 cm
gm2_2017_0.20cm_Potassium_aa	The amount of K in grams per meter squared in 2017 of exchangeable potassium using soil collected from 0-20 cm
AbvBioAnnProd.2015.2017	The amount in grams per meter squared of aboveground biomass as the average of 2015 and 2017
Root030cm.2015.2017	The amount in grams per meter squared of root biomass collected 0-30 cm deep as the average of 2015 and 2017
TotalProd.2015.2017	The sum of aboveground and belowground biomass in grams per meter squared as the average of 2015 and 2017
Nitrogen_gm2_Abv	The amount of nitrogen as grams per meter squared of N in aboveground biomass. N was measured in 2017 and multiplied by the average aboveground biomass measured in 2015 and 2017
Phosphorus_gm2_Abv	The amount of phosphorus as grams per meter squared of P in aboveground biomass. P was measured in 2017 and multiplied by the average aboveground biomass measured in 2015 and 2017
Potassium_gm2_Abv	The amount of potassium as grams per meter squared of K in aboveground biomass. K was measured in 2017 and multiplied by the average aboveground biomass measured in 2015 and 2017
Magnesium_gm2_Abv	The amount of magnesium as grams per meter squared of Mg in aboveground biomass. Mg was measured in 2017 and multiplied by the average aboveground biomass measured in 2015 and 2017
Calcium_gm2_Abv	The amount of calcium as grams per meter squared of Ca in aboveground biomass. Ca was measured in 2017 and multiplied by the average aboveground biomass measured in 2015 and 2017
Nitrogen_gm2_Root.0.30cm	The amount of nitrogen as grams per meter squared of N in belowground biomass. N was measured in 2017 and multiplied by the average belowground biomass (0-30 cm) measured in 2015 and 2017

Phosphorus_gm2_Root.0.30cm	The amount of phosphorus as grams per meter squared of P in belowground biomass. P was measured in 2017 and multiplied by the average belowground biomass (0-30 cm) measured in 2015 and 2017
Potassium_gm2_Root.0.30cm	The amount of potassium as grams per meter squared of K in belowground biomass. K was measured in 2017 and multiplied by the average belowground biomass (0-30 cm) measured in 2015 and 2017
Magnesium_gm2_Root.0.30cm	The amount of magnesium as grams per meter squared of Mg in belowground biomass. Mg was measured in 2017 and multiplied by the average belowground biomass (0-30 cm) measured in 2015 and 2017
Calcium_gm2_Root.0.30cm	The amount of calcium as grams per meter squared of Ca in belowground biomass. Ca was measured in 2017 and multiplied by the average belowground biomass (0-30 cm) measured in 2015 and 2017
Calcium_total.soil.plant.g.m2	The sum of the difference in soil calcium in grams of Ca per meter squared at 0-20 cm deep from 1994-2017, the amount of calcium in aboveground biomass in grams per meter squared and the amount of calcium in belowground biomass in grams per meter squared.
Magnesium_total.soil.plant.g.m2	The sum of the difference in soil magnesium in grams of Mg per meter squared at 0-20 cm deep from 1994-2017, the amount of magnesium in aboveground biomass in grams per meter squared and the amount of magnesium in belowground biomass in grams per meter squared.
Nitrogen_total.soil.plant.g.m2	The sum of the difference in soil nitrogen in grams of N per meter squared at 0-20 cm deep from 1994-2017, the amount of nitrogen in aboveground biomass in grams per meter squared and the amount of nitrogen in belowground biomass in grams per meter squared.
Phosphorus_total.soil.plant.g.m2	The sum of the difference in soil phosphorus in grams of P per meter squared at 0-20 cm deep from 1994-2017, the amount of phosphorus in aboveground biomass in

	grams per meter squared and the amount of phosphorus in belowground biomass in grams per meter squared.
Potassium_total.soil.plant.g.m2	The sum of the difference in soil potassium in grams of K per meter squared at 0-20 cm deep from 1994-2017, the amount of potassium in aboveground biomass in grams per meter squared and the amount of potassium in belowground biomass in grams per meter squared.

[1] Total C and total N represent the average of 2015 and 2017 measured values.

Dataset_S2
Figures: Fig. 4
Comment: This dataset contains mean plant tissue chemical traits, using dried biomass, measured at the species level in plots of the biodiversity experiment (E120). Root biomass was measured as the mean of all monoculture plots for each species across all years. Root biomass has been sampled in years 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2006, 2010, 2015 and 2017.

Variable	Metadata
Species	The plant species
func	The functional group of that plant species. F = forb; L = legume; C3 = C3 grass; C4 = C4 grass
Calcium	The mean aboveground tissue calcium in %
Magnesium	The mean aboveground tissue magnesium in %
Nitrogen	The mean aboveground tissue nitrogen in %
Phosphorus	The mean aboveground tissue phosphorus in %
Potassium	The mean aboveground tissue potassium in %
RootBiomass	The mean belowground root biomass (0-30 cm) across all monoculture plots for each species measured in grams per meter squared from all available data across all years

Dataset_S3
Figures: Figure S3, S4 and S5
Comment: This dataset contains soil nutrients measured in dry soil from each plot

Variable	Metadata
Plot	The experimental plot
NumSp	The number of species planted in a plot
Depth	The depth of the soil sample in centimeters
Year	The year the soil samples were collected: 1994 or 2017. Total C and total N represent the average of 2015 and 2017 measured values.
nut	The nutrient measured
val	The measured value of the soil sample
unit	The corresponding unit of each sample where: mgX.kgSoil = milligrams of nutrient x per kilogram of soil; meq.100gSoil = milliequivalents per 100 g soil; log.H = -log[H+].

Dataset_S4

Comment: This dataset contains soil nutrient content and soil bulk density. It can be used to reproduce the conversion of the soil concentration data to the grams per meter squared values used in Dataset_S1. Note that in several cases 2017 is the "year" denoted as the reference year when either 2018[1] (bulk density) or the average 2015 and 2017 were used (total C[2] and N[2]).

Variable	Metadata
Nutrient	The nutrient measured in the soil
Plot	The experimental plot
NumSp	The number of species planted in a plot
unit	The corresponding unit of each sample where: mgX.kgSoil = milligrams of nutrient x per killigram of soil; meq.100gSoil = milliequivalents per 100 g soil; log.H = -log[H+].
X0.20cm_1994	The value of a given nutrient x measured in the soil from 0-20 cm depth in 1994
X0.20cm_2017	The value of a given nutrient x measured in the soil from 0-20 cm depth in 2017
X20.40cm_2017	The value of a given nutrient x measured in the soil from 20-40 cm depth in 2017
Bulk.Density.g.cm3_0.20cm_1994	Predicted soil bulk density values in grams per centimeter cubed derived from a linear regression of the dependency of bulk density[1] in 2018 (0-20 cm depth) on total soil carbon[2] 2017 (0-20 cm depth) using measured values of total soil carbon in 1994.
Bulk.Density.g.cm3_0.20cm_2017	A combination of measured soil bulk density in 2018 in grams per centimeter cubed (0-20 cm depth) and predicted soil bulk density values (0-20 cm depth) in grams per centimeter cubed derived from a linear regression of the dependency of bulk density[1] in 2018 (0-20 cm depth) on total soil carbon[2] 2017 (0-20 cm depth) using measured values of total soil carbon in 2017.
Bulk.Density.g.cm3_20.40cm_2017	A combination of measured soil bulk density in 2018 in grams per centimeter cubed (20-40 cm depth) and predicted soil bulk density values (20-40 cm depth) in grams per centimeter cubed derived from a linear regression of the dependency of bulk density[1] in 2018 (20-40 cm depth) on total soil carbon[2] 2017 (0-20 cm depth) using measured values of total soil carbon in 2017.
bd.pred	A variable denoting whether the value for bulk density was one of 87 plots measured in 2018 or a predicted value from a linear regression with total soil carbon[2]. "measured" =

	measured plot; "predicted" = derived from a linear regression.
Depth_add_cm	The quantity of added or subtracted soil depth in centimeters in 2017 to give equivalent mass based on the difference in soil bulk density at 0-20 cm depth from 1994
gm2_1994_0.20cm	The quantity in grams per meter squared of a given element x in the soil 0-20 cm depth in 1994
gm2_2017_u	The quantity in grams per meter squared of a given element x in the soil 0-20 cm depth in 2017 uncorrected for changes in bulk density
gm2_2017_add	The quantity in grams per meter squared of a given element x in the soil 0-20 cm depth in 2017 to add or subtract to provide equivalent mass
gm2_2017_0.20cm	The quantity in grams per meter squared of a given element x in the soil 0-20 cm depth in 2017 corrected using the equivalent soil mass method.

[1] Bulk density was measured in 2018

[2] Total C and total N represent the average of 2015 and 2017 measured values.

Dataset_S5

Comment: This dataset contains plant tissue concentrations measured in each plot. It can be used to reproduce the conversion of tissue concentrations to area density quantities.

Variable	Metadata
Plot	The experimental plot
Nutrient	The nutrient element measured in biomass
Extract	Denoting that an acid digest was used
Type	A variable coding indicating whether the measured concentration of each element represents either aboveground or belowground biomass (0-30 cm depth) measured in 2017. "p.abv" = aboveground; "p.Root0.30cm" = belowground root biomass (0-30 cm depth).
Year	The year the sample was collected
val	The concentration of each nutrient in g of element x per g of dry biomass
Biomass	Depending on type: The amount in grams per meter squared of dry aboveground biomass as the average of 2015 and 2017; The amount in grams per meter squared of dry root biomass collected 0-30 cm deep as the average of 2015 and 2017
val.g	The amount in grams per meter squared of each element calculated by multiplying "val" and "Biomass".

Dataset_S6
Figures: Fig. 2
Comment: This dataset contains plant tissue area density quantities in each plot. It can be used to reproduce the derived response variables in Fig. 2 as the percent change from the monoculture mean.

Variable	Metadata
Plot	The experimental plot
NumSp	The number of species planted in a plot, which is its diversity treatment
nut	The nutrient measured in above or belowground biomass
type	A variable coding indicating whether the measured percent of each element represents either dry aboveground or dry belowground biomass (0-30 cm) measured in 2017. "p.abv" = aboveground; "p.Root0.30cm" = belowground root biomass (0-30 cm).
val.g	The amount in grams per meter squared of each element in dry aboveground or dry belowground biomass (0-30 cm)
mono	The monoculture mean of "val.g" for each nutrient
diff	For each plot and nutrient, “diff” is the percent change in the “val.g” of a nutrient in a plot from the 2017 mean “val.g” of that nutrient across all monoculture plots. Formula used = ((val.g - mono)/(mono))*100

Dataset S7
Figures: Figure S10
Comment: This dataset contains species-specific plant tissue chemical traits and root mass, as measured in plots of the biodiversity experiment (E120). Root biomass is the species-specific mean across all monoculture plots and all measured years for each species. Root biomass was measured in years 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2006, 2010, 2015 and 2017.

Variable	Metadata
Plot	The experimental plot
func	The functional group of that plant species. F = forb; L = legume; C3 = C3 grass; C4 = C4 grass
NumSp	The number of species of the plot where the plant trait measurement was taken
Species	The plant species measured
nut	The trait variable measured of either the total aboveground percent nitrogen, phosphorus, potassium, calcium or magnesium for each species or the mean monoculture root biomass (0-30 cm) of each species' monoculture.
val	The measured quantity of each trait. Either the percent nutrient in dry aboveground biomass or the dry root biomass in grams per meter squared at 0-30 cm deep.