



Supplementary Information for

Asynchronous nitrogen supply and demand produce non-linear plant allocation responses to warming and elevated CO₂

Genevieve L. Noyce, Matthew L. Kirwan, Roy L. Rich, and J. Patrick Megonigal

Genevieve Noyce

Email: noyceg@si.edu

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Fig. S1. SMARTX transect showing aboveground infrared heaters (foreground) and open-top elevated CO₂ (eCO₂) chamber (background). Heating cables extend 1.5 m into the soil and are located every 50 cm.

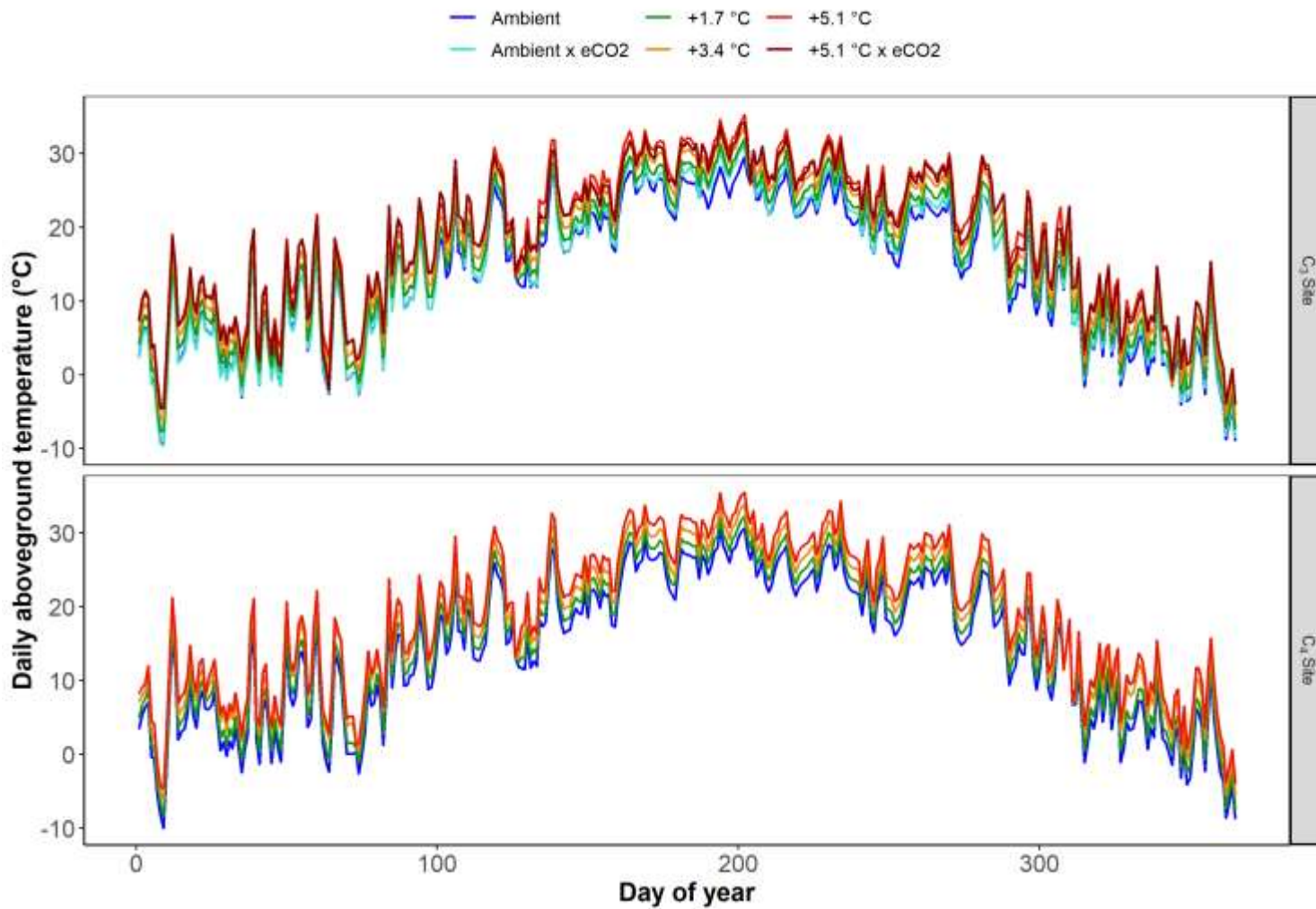


Fig. S2. Daily aboveground temperature in 2017 from each SMARTX treatment. Lines are the means of three replicate plots. Standard error is not shown because it is not visible at this scale.

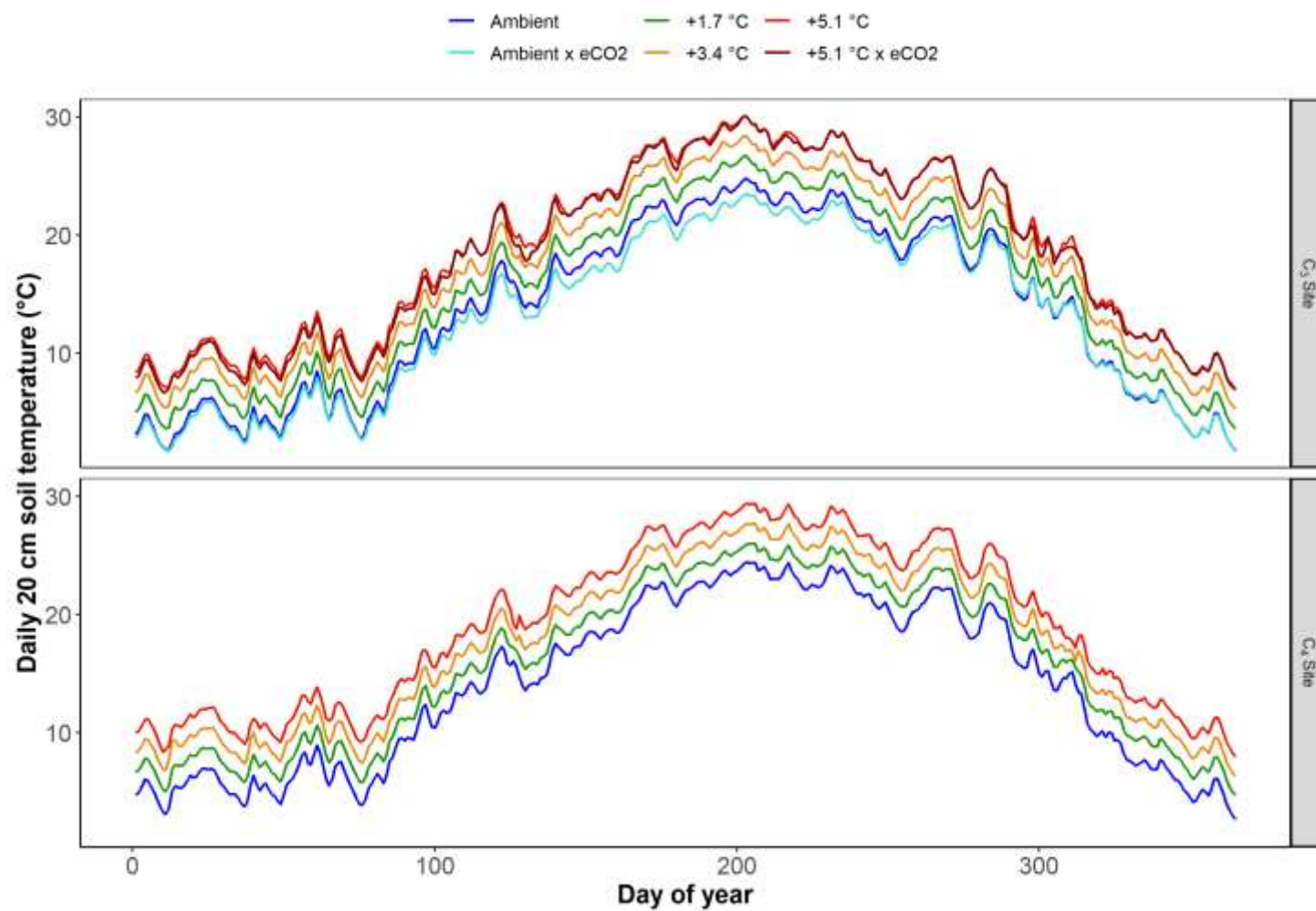


Fig. S3. Daily soil temperature in 2017 measured at 20 cm depth from each SMARTX treatment. Lines are the means of three replicate plots. Standard error is not shown because it is not visible at this scale.

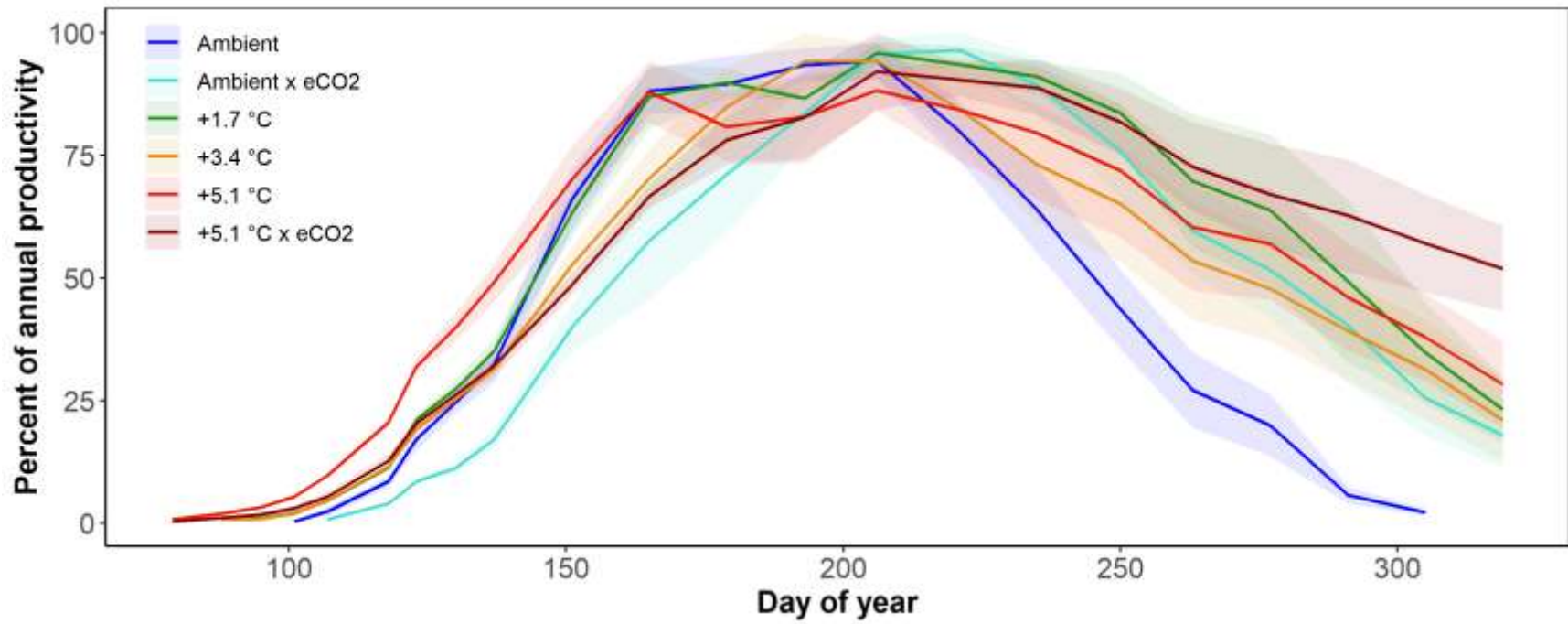


Fig. S4. Percent of total annual productivity that was present in SMARTX plots each week. Lines are the means of three replicate plots and shading is ± 1 standard error.

Table S1. Type III ANOVA tables for mixed effects models in the C₃ community with temperature treatment as a fixed effect and year and transect as random effects. *P*-values calculated using Satterthwaite's method.

Response	Sum Sq	Mean Sq	Num df	Den df	<i>F</i>	<i>P</i>
Total NPP	32559	10853	3	15	1.670	0.216
Above NPP	40456	13485	3	15	1.968	0.162
Belowground NPP	24774	8258	3	15	4.637	0.017
Root-to-shoot ratio	0.3857	0.1252	3	15	4.524	0.019
Plant N [†]	11876	3958.6	3	8	0.7315	0.562
Porewater NH ₄	46846	15614	3	15	3.924	0.030

[†]Based on 2017 data only.

Table S2. Mixed effects model results of biomass and porewater NH₄⁺ response variables in the C₃ community, as predicted by warming treatment (reference category: ambient temperature).

Response	Fixed effects terms	Estimate	SE	df	<i>t</i>	<i>P</i>
Total NPP	Intercept (ambient)	495.5	35.27	19	14.05	<0.001
	+1.7 °C	74.67	46.54	15	1.604	0.129
	+3.4 °C	64.13	46.54	15	1.378	0.188
	+5.1 °C	99.93	46.54	15	2.147	0.049
Above NPP	Intercept (ambient)	423.8	46.41	12	9.131	<0.001
	+1.7 °C	-5.183	47.79	15	-0.108	0.915
	+3.4 °C	40.55	47.79	15	0.849	0.410
	+5.1 °C	97.33	47.79	15	2.037	0.059
Belowground NPP	Intercept (ambient)	71.72	21.80	14	3.289	0.005
	+1.7 °C	79.82	24.37	15	3.277	0.005
	+3.4 °C	23.58	24.37	15	0.968	0.348
	+5.1 °C	2.583	24.37	15	0.106	0.917
Root-to-shoot ratio	Intercept (ambient)	0.182	0.091	12	2.008	0.066
	+1.7 °C	0.287	0.096	15	2.983	0.009
	+3.4 °C	0.061	0.096	15	0.637	0.534
	+5.1 °C	-0.035	0.096	15	-0.364	0.721
Plant N [†]	Intercept (ambient)	409.7	42.47	8	9.647	<0.001
	+1.7 °C	65.57	60.06	8	1.092	0.307
	+3.4 °C	61.50	60.06	8	1.024	0.336
	+5.1 °C	83.33	60.06	8.00	1.387	0.203
Porewater NH ₄	Intercept (ambient)	176.0	27.11	19	6.494	<0.001
	+1.7 °C	-62.15	36.42	15	-1.707	0.108
	+3.4 °C	25.02	36.42	15	0.687	0.503
	+5.1 °C	58.60	36.42	15	1.609	0.128

[†]Based on 2017 data only.

Table S3. Type III ANOVA tables for mixed effects models in the C₄ community with temperature treatment as a fixed effect and year and transect as random effects. *P*-values calculated using Satterthwaite's method.

Response	Sum Sq	Mean Sq	Num df	Den df	<i>F</i>	<i>P</i>
Total NPP	24199	8066	3	15	0.617	0.615
Above NPP	16936	5646	3	15	0.355	0.786
Belowground NPP	1226.8	408.9	3	15	0.431	0.734
Root-to-shoot ratio	0.0192	0.006	3	15	0.359	0.784
Porewater NH ₄	13356	4452	3	15	3.28	0.050

Table S4. Mixed effects model results of biomass and porewater NH₄⁺ response variables in the C₄ community, as predicted by warming treatment (reference category: ambient temperature).

Response	Fixed effects terms	Estimate	SE	df	<i>t</i>	<i>P</i>
Total NPP	Intercept (ambient)	561.2	75.59	9	7.424	<0.001
	+1.7 °C	24.32	66.00	15	0.368	0.718
	+3.4 °C	-52.08	66.00	15	-0.789	0.442
	+5.1 °C	-45.52	66.00	15	-0.690	0.501
Above NPP	Intercept (ambient)	435.0	71.73	11	6.064	<0.001
	+1.7 °C	15.55	72.79	15	0.214	0.834
	+3.4 °C	-51.37	72.79	15	-0.706	0.491
	+5.1 °C	-34.15	72.79	15	-0.469	0.646
Belowground NPP	Intercept (ambient)	126.2	15.41	17	8.192	<0.001
	+1.7 °C	8.800	17.78	15	0.495	0.628
	+3.4 °C	-0.717	17.78	15	-0.040	0.968
	+5.1 °C	-11.37	17.78	15	-0.639	0.532
Root-to-shoot ratio	Intercept (ambient)	0.296	0.055	19	5.343	<0.001
	+1.7 °C	0.078	0.077	15	1.105	0.326
	+3.4 °C	0.051	0.077	15	0.666	0.515
	+5.1 °C	0.036	0.077	15	0.465	0.649
Porewater NH ₄	Intercept (ambient)	297.8	25.69	8	11.591	<0.001
	+1.7 °C	-7.550	21.27	15	-0.355	0.728
	+3.4 °C	-52.03	21.27	15	-2.446	0.027
	+5.1 °C	-49.18	21.27	15	-2.312	0.035

Table S5. Mean values per temperature treatment and year (visually displayed in Figures 1, 2, 3, and 4 in the main text). Means within a given year that do not share a letter are significantly different at $\alpha = 0.05$.

C₃ community								
Temperature	2017				2018			
	Amb	+1.7 °C	+3.4 °C	+5.1 °C	Amb	+1.7 °C	+3.4 °C	+5.1 °C
Total NPP	464.9 ^a	528.1 ^a	494.7 ^a	567.8 ^a	526.2 ^a	612.2 ^a	624.6 ^a	623.1 ^a
Above NPP	367.1 ^a	320.6 ^a	359.0 ^a	479.5 ^a	480.5 ^a	516.6 ^a	569.7 ^a	562.8 ^a
Below NPP	97.8 ^a	207.5 ^b	135.7 ^{ab}	88.3 ^a	45.7 ^a	95.6 ^a	54.9 ^a	60.3 ^a
Root-to-shoot	0.269 ^a	0.732 ^b	0.392 ^{ab}	0.190 ^a	0.096 ^a	0.205 ^a	0.095 ^a	0.105 ^a
Plant N	409.7 ^a	475.3 ^a	471.2 ^a	493.1 ^a	--	--	--	--
NH ₄	197.7 ^{ab}	126.0 ^a	181.1 ^{ab}	217.3 ^b	154.3 ^a	101.8 ^a	221.1 ^a	252.0 ^a
C₄ community								
Temperature	2017				2018			
	Amb	+1.7 °C	+3.4 °C	+5.1 °C	Amb	+1.7 °C	+3.4 °C	+5.1 °C
Total NPP	483.3 ^b	420.6 ^{ab}	381.9 ^{ab}	329.4 ^a	639.0 ^a	750.4 ^a	636.2 ^a	701.9 ^a
Above NPP	377.8 ^b	285.0 ^{ab}	290.0 ^{ab}	232.8 ^a	492.1 ^a	616.0 ^a	477.0 ^a	568.8 ^a
Below NPP	105.5 ^{ab}	135.6 ^b	92.1 ^a	96.6 ^a	146.9 ^a	134.4 ^a	158.9 ^a	133.1 ^a
Root-to-shoot	0.287 ^a	0.488 ^b	0.333 ^{ab}	0.421 ^{ab}	0.305 ^a	0.261 ^a	0.361 ^a	0.243 ^a
NH ₄	263.8 ^a	255.4 ^a	208.7 ^a	218.5 ^a	331.8 ^a	325.1 ^a	282.9 ^a	278.8 ^a

Table S6. Type III ANOVA tables for mixed effects models in the C₃ community with temperature treatment and CO₂ treatment as fixed effects and year and transect as random effects. *P*-values calculated using Satterthwaite's method.

Response	Factor	Sum Sq	Mean Sq	Num df	Den df	<i>F</i>	<i>P</i>
Total NPP	Temp	33153	33153	1	20	4.188	0.054
	<i>e</i> CO ₂	110378	110378	1	20	13.94	0.001
	Temp × <i>e</i> CO ₂	3932	3932	1	20	0.497	0.489
Above NPP	Temp	17664	17664	1	15	2.730	0.119
	<i>e</i> CO ₂	12344	12344	1	15	1.908	0.188
	Temp × <i>e</i> CO ₂	11133	11133	1	15	1.720	0.209
Belowground NPP	Temp	2416	2416	1	15	1.464	0.245
	<i>e</i> CO ₂	48925	48925	1	15	29.65	<0.001
	Temp × <i>e</i> CO ₂	1834	1834	1	15	1.111	0.309
Root-to-shoot ratio	Temp	0.0039	0.0039	1	15	0.448	0.513
	<i>e</i> CO ₂	0.1697	0.1697	1	15	19.50	<0.001
	Temp × <i>e</i> CO ₂	0.0220	0.0220	1	15	2.523	0.133
Plant N [†]	Temp	580	580	1	8	0.036	0.854
	<i>e</i> CO ₂	129086	129086	1	8	8.078	0.022
	Temp × <i>e</i> CO ₂	14463	14463	1	8	0.905	0.369
Porewater NH ₄	Temp	63191	63191	1	20	10.86	0.004
	<i>e</i> CO ₂	31472	31472	1	20	5.410	0.031
	Temp × <i>e</i> CO ₂	11629	11629	1	20	1.999	0.173

[†]Based on 2017 data only.

Table S7. Mixed effects model results of biomass and porewater NH_4^+ response variables in the C_3 community, as predicted by warming treatment and CO_2 treatment (reference category: ambient temperature, ambient CO_2).

Response	Fixed effects terms	Estimate	SE	df	<i>t</i>	<i>P</i>
Total NPP	Intercept (ambient)	495.5	36.32	20	13.64	<0.001
	+5.1 °C	99.93	51.37	20	1.945	0.066
	$e\text{CO}_2$	161.2	51.37	20	3.139	0.005
	+5.1 °C \times $e\text{CO}_2$	-51.20	72.65	20	-0.705	0.489
Above NPP	Intercept (ambient)	423.8	35.69	18	11.87	<0.001
	+5.1 °C	97.33	46.44	15	2.096	0.053
	$e\text{CO}_2$	88.43	46.44	15	1.904	0.076
	+5.1 °C \times $e\text{CO}_2$	-86.15	65.68	15	-1.312	0.209
Belowground NPP	Intercept (ambient)	71.72	24.49	10	2.928	0.014
	+5.1 °C	2.583	23.45	15	0.110	0.914
	$e\text{CO}_2$	72.82	23.45	15	3.105	0.007
	+5.1 °C \times $e\text{CO}_2$	34.97	33.17	15	1.05	0.308
Root-to-shoot ratio	Intercept (ambient)	0.182	0.061	9	2.976	0.015
	+5.1 °C	-0.035	0.054	15	-0.650	0.526
	$e\text{CO}_2$	0.108	0.054	15	1.999	0.064
	+5.1 °C \times $e\text{CO}_2$	0.121	0.076	15	1.589	0.133
Plant N^\ddagger	Intercept (ambient)	409.7	72.98	8	5.614	<0.001
	+5.1 °C	83.33	103.2	8	0.807	0.443
	$e\text{CO}_2$	276.9	103.2	8	2.682	0.028
	+5.1 °C \times $e\text{CO}_2$	-138.9	146.0	8	-0.951	0.369
Porewater NH_4	Intercept (ambient)	176.0	31.14	20	5.653	<0.001
	+5.1 °C	58.6	44.04	20	1.331	0.198
	$e\text{CO}_2$	-116.4	44.04	20	-2.644	0.016
	+5.1 °C \times $e\text{CO}_2$	88.05	62.28	20	1.414	0.172

[‡]Only using 2017 data.

Table S8. Mean values per temperature x CO₂ treatment and year (visually displayed in Figures 1, 2 and 4 in the main text). Different letters indicate significant (at $\alpha = 0.05$) effects of elevated CO₂ within a temperature treatment.

	2017				2018			
	Ambient		+5.1 °C		Ambient		+5.1 °C	
	Amb CO ₂	Elev CO ₂	Amb CO ₂	Elev CO ₂	Amb CO ₂	Elev CO ₂	Amb CO ₂	Elev CO ₂
Total NPP	464.9 ^a	704.9 ^b	567.8 ^a	716.8 ^b	526.2 ^a	608.6 ^a	623.1 ^a	694.2 ^a
Above NPP	367.1 ^a	524.4 ^b	479.5 ^a	464.1 ^a	480.5 ^a	500.1 ^a	562.8 ^a	582.8 ^a
Below NPP	97.8 ^a	180.5 ^b	88.3 ^a	252.8 ^b	45.7 ^a	108.5 ^b	60.3 ^a	111.4 ^a
Root-to-shoot	0.269 ^a	0.353 ^a	0.190 ^a	0.560 ^b	0.096 ^a	0.227 ^b	0.105 ^a	0.192 ^a
Plant N	409.7 ^a	686.6 ^b	493.1 ^a	631.1 ^b	--	--	--	--
NH ₄	197.7 ^a	76.7 ^b	217.3 ^b	152.3 ^a	154.3 ^a	42.5 ^b	252.0 ^a	260.2 ^a