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Dissolved carbon flow to particulate organic carbon enhances soil carbon sequestration

Qintana Si et al.

Correspondence to: Junyi Liang (liangjunyi@cau.edu.cn)

Table S1. The amount of carbon (C) input of different sites in modeling experiments.

Site	DOC input only (g C kg^{-1} soil $year^{-1}$)		DOC+POC input (g C kg^{-1} soil $year^{-1}$)	
	DOC	POC	DOC	POC
$DL_{fencing}$	10	0	10	10
$DL_{grazing}$	10	0	10	10
$GY_{fencing}$	4	0	4	4
$GY_{grazing}$	4	0	4	4
$HL_{fencing}$	2	0	2	2
$HL_{grazing}$	2	0	2	2
$XL_{fencing}$	2	0	2	2
$XL_{grazing}$	2	0	2	2
$XH_{fencing}$	2	0	2	2
$XH_{grazing}$	2	0	2	2

Table S2. Results of the two-way analysis of variance (ANOVA) on the effects of sites, fencing, and their interaction (sites: fencing) on plant aboveground biomass, initial MBC, SOC, and soil texture.

	Df	Sum Sq	*F*-value	*P*-value
Aboveground biomass				
Sites	4	1.52×10^{5}	2.14×10^{1}	**<0.001**
Fencing	1	2.66×10^{5}	1.50×10^{2}	**<0.001**
Sites: Fencing	4	1.20×10^{5}	1.69×10^{1}	**<0.001**
Residuals	50	8.87×10^{4}		
Initial MBC				
Sites	4	1.40	7.17×10^{1}	**<0.001**
Fencing	1	2.92×10^{-2}	5.98	**<0.05**
Sites: Fencing	4	3.04×10^{-2}	1.56	0.211
Residuals	30	1.46×10^{-1}		
Initial SOC				
Sites	4	1.04×10^{4}	5.36×10^{2}	**<0.001**
Fencing	1	9.40×10^{1}	1.94×10^{1}	**<0.001**
Sites: Fencing	4	1.31×10^{2}	6.74	**<0.01**
Residuals	20	9.70×10^{1}		
Soil texture (Silt and clay)				
Sites	4	3.67×10^{3}	3.70×10^{2}	**<0.001**
Fencing	1	1.60×10^{1}	6.32	**<0.05**
Sites: Fencing	4	4.80×10^{1}	4.87	**<0.05**
Residuals	10	2.50×10^{1}		

Table S3. Results of the two-way ANOVA on the effects of sites, fencing, and their interaction (sites: fencing) on glucose-derived SOC, MAOC, POC, MBC, DOC, and cumulative respiration. Cumulative respiration is the total respiration for 102d incubation calculated from the CO_2 emission rates. The SOC content is the sum of the sizes of the other four C pools combined.

	Df	Sum Sq	*F*-value	*P*-value
Glucose-derived SOC				
Sites	4	3.85×10^{-2}	1.10×10^{2}	**<0.001**
Fencing	1	9.00×10^{-5}	9.75×10^{-1}	0.331
Sites: Fencing	4	9.00×10^{-4}	2.58	0.058
Residuals	30	2.62×10^{-3}		
Glucose-derived MAOC				
Sites	4	3.94×10^{-3}	3.95×10^{1}	**<0.001**
Fencing	1	3.18×10^{-4}	1.27×10^{1}	**<0.01**
Sites: Fencing	4	4.78×10^{-4}	4.79	**<0.01**
Residuals	30	7.48×10^{-4}		
Glucose-derived POC				
Sites	4	7.15×10^{-3}	1.74×10^{2}	**<0.001**
Fencing	1	4.00×10^{-5}	3.85	0.059
Sites: Fencing	4	7.78×10^{-4}	1.90×10^{1}	**<0.001**
Residuals	30	3.08×10^{-4}		
Glucose-derived MBC				
Sites	4	4.43×10^{-3}	1.83×10^{1}	**<0.001**
Fencing	1	6.00×10^{-6}	1.02×10^{-1}	0.752
Sites: Fencing	4	2.28×10^{-4}	9.37×10^{-1}	0.456
Residuals	30	1.82×10^{-3}		
Glucose-derived DOC				
Sites	4	1.62×10^{-7}	8.89	**<0.001**
Fencing	1	3.42×10^{-8}	7.50	**<0.05**
Sites: Fencing	4	5.08×10^{-8}	2.78	**<0.05**
Residuals	30	1.37×10^{-7}		
Cumulative respiration				
Sites	4	1.21×10^{3}	2.05×10^{2}	**<0.001**
Fencing	1	8.40	5.67	**<0.05**
Sites: Fencing	4	1.38×10^{1}	2.33	0.079
Residuals	30	4.44×10^{1}		

Table S4. Multiple linear regression of cumulative respiration and glucose-derived SOC. Cumulative respiration is the total respiration for 102d incubation calculated from CO_2 emission rates rate. Soil texture was represented by the sum of clay and silt content.

	Estimate	Std.Error	t value	P
Cumulative respiration ~ soil texture + SOC, Multiple R^2=0.8743, Adjusted R^2=0.8384				
Intercept	6.229	1.842	3.382	<0.05
soil texture	-0.381	0.088	-4.349	<0.01
SOC	0.357	0.051	6.978	<0.001
Glucose-derived SOC ~ soil texture, Multiple R^2=0.9185, Adjusted R^2=0.9083				
Intercept	0.056	0.008	7.203	<0.001
soil texture	0.003	0.000	9.497	<0.001

Table S5. The posterior maximum likelihood estimates (MLE) of the parameters.

Parameter	$DL_{fencing}$		$DL_{grazing}$		$GY_{fencing}$		$GY_{grazing}$		$HL_{fencing}$	
	model I	model II	model I	model II	model I	model II	model I	model II	model I	model II
$f_{heavy-POC}$	0.145	0.170	0.175	0.214	0.112	0.098	0.166	0.160	0.193	0.187
$f_{light\ fraction}$	0.049	0.053	0.094	0.104	0.052	0.044	0.046	0.047	0.112	0.080
k_D	7.21×10^{-3}	6.97×10^{-3}	1.50×10^{-2}	1.53×10^{-2}	4.34×10^{-3}	4.88×10^{-3}	6.88×10^{-3}	6.39×10^{-3}	1.38×10^{-2}	1.53×10^{-2}
k_B	6.62×10^{-4}	6.61×10^{-4}	7.77×10^{-4}	7.67×10^{-4}	7.50×10^{-4}	7.03×10^{-4}	7.76×10^{-4}	7.74×10^{-4}	6.93×10^{-4}	7.28×10^{-4}
k_H	3.17×10^{-4}	3.32×10^{-4}	1.56×10^{-4}	1.88×10^{-4}	1.34×10^{-4}	1.56×10^{-4}	1.19×10^{-4}	1.10×10^{-4}	6.78×10^{-5}	6.14×10^{-5}
k_L	5.32×10^{-4}	4.25×10^{-4}	5.55×10^{-4}	4.74×10^{-4}	1.71×10^{-4}	2.17×10^{-4}	4.73×10^{-3}	2.97×10^{-3}	5.54×10^{-5}	1.17×10^{-4}
k_M	1.23×10^{-4}	1.21×10^{-4}	5.18×10^{-5}	3.99×10^{-5}	1.05×10^{-4}	9.33×10^{-5}	7.69×10^{-5}	6.24×10^{-5}	8.43×10^{-6}	7.05×10^{-6}
f_{BD}	0.574	0.566	0.583	0.579	0.504	0.419	0.541	0.548	0.547	0.575
f_{MB}	0.510	0.508	0.411	0.405	0.487	0.564	0.455	0.439	0.504	0.448
f_{DM}	0.148	0.084	0.261	0.283	0.082	0.063	0.351	0.376	0.526	0.473
f_{DL}	0.223	0.180	0.115	0.129	0.276	0.283	0.234	0.266	0.556	0.552
f_{DH}	0.042	0.135	0.134	0.120	0.370	0.437	0.100	0.157	0.559	0.558
f_{MH}	0.075	0.095	0.090	0.095	0.151	0.141	0.094	0.104	0.555	0.415
f_{HB}	-	0.146	-	0.164	-	0.147	-	0.078	-	0.258

Parameter	$HL_{grazing}$		$XL_{fencing}$		$XL_{grazing}$		$XH_{fencing}$		$XH_{grazing}$	
	model I	model II	model I	model II	model I	model II	model I	model II	model I	model II
$f_{heavy-POC}$	0.196	0.220	0.244	0.223	0.098	0.099	0.125	0.127	0.127	0.124
$f_{light\ fraction}$	0.026	0.025	0.055	0.056	0.025	0.025	0.025	0.026	0.025	0.025
k_D	1.27×10^{-2}	1.59×10^{-2}	1.29×10^{-2}	1.32×10^{-2}	1.20×10^{-2}	1.20×10^{-2}	2.99×10^{-2}	3.28×10^{-2}	2.52×10^{-2}	2.79×10^{-2}
k_B	8.31×10^{-4}	8.66×10^{-4}	8.39×10^{-4}	8.57×10^{-4}	6.08×10^{-4}	6.24×10^{-4}	1.69×10^{-2}	2.17×10^{-2}	5.67×10^{-3}	1.31×10^{-2}
k_H	8.00×10^{-5}	9.75×10^{-5}	6.46×10^{-5}	8.29×10^{-5}	1.11×10^{-4}	1.18×10^{-4}	4.02×10^{-3}	3.69×10^{-3}	3.67×10^{-3}	4.50×10^{-3}
k_L	1.93×10^{-4}	1.19×10^{-4}	1.77×10^{-4}	1.46×10^{-4}	1.10×10^{-4}	1.13×10^{-4}	5.18×10^{-3}	5.08×10^{-3}	5.19×10^{-3}	4.44×10^{-3}
k_M	8.36×10^{-6}	5.67×10^{-6}	4.77×10^{-5}	4.40×10^{-5}	3.55×10^{-5}	3.49×10^{-5}	4.62×10^{-4}	4.97×10^{-4}	6.10×10^{-4}	7.07×10^{-4}
f_{BD}	0.789	0.789	0.645	0.645	0.698	0.689	0.756	0.756	0.815	0.805
f_{MB}	0.375	0.365	0.342	0.343	0.333	0.318	0.372	0.370	0.506	0.477
f_{DM}	0.546	0.492	0.548	0.539	0.498	0.491	0.560	0.523	0.610	0.501
f_{DL}	0.336	0.379	0.429	0.458	0.248	0.245	0.434	0.434	0.446	0.498
f_{DH}	0.658	0.647	0.603	0.625	0.396	0.380	0.566	0.586	0.586	0.620
f_{MH}	0.131	0.123	0.072	0.116	0.098	0.096	0.269	0.306	0.509	0.527
f_{HB}	-	0.135	-	0.031	-	0.287	-	0.296	-	0.398

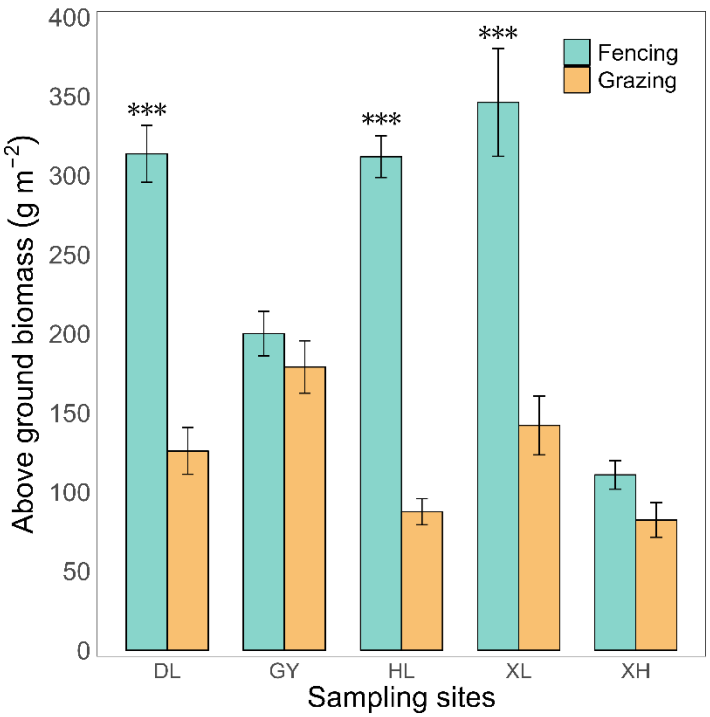

Figure S1. **Plant aboveground biomass in fencing and grazing grasslands across the five sampling sites.** Error bars represent the standard errors of six replicates.

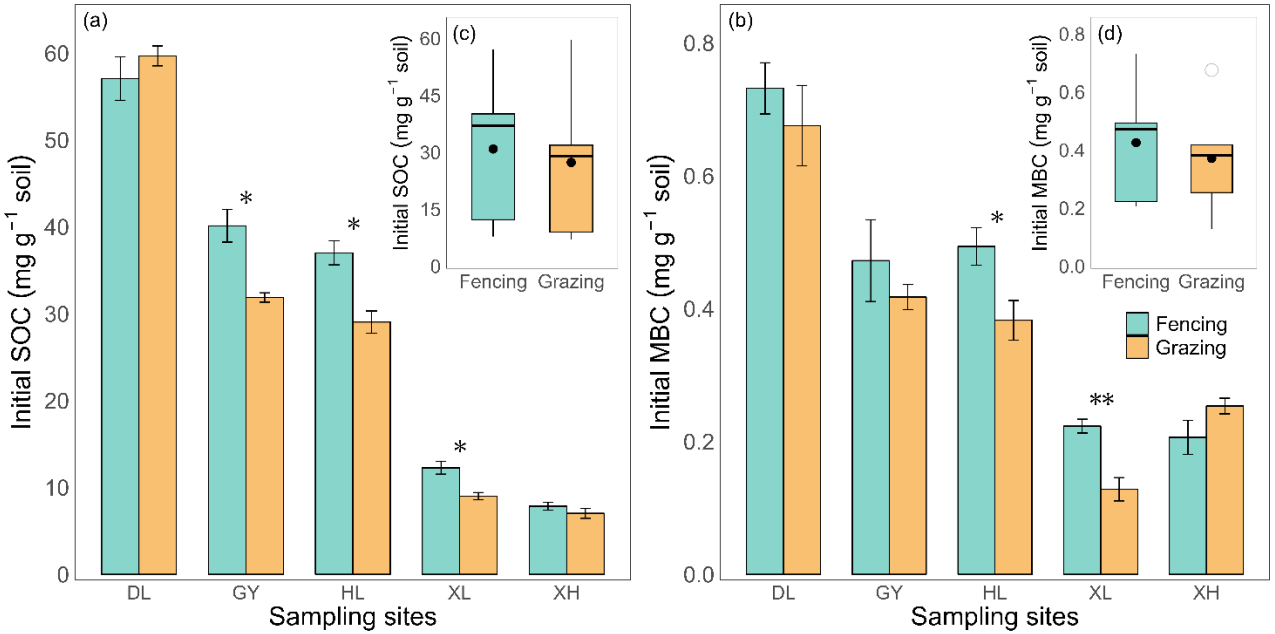

Figure S2. **Initial SOC (a) and MBC (b) in fencing and grazing grasslands across the five sampling sites.** Error bars represent the standard errors of three replicates for initial SOC and four replicates for initial MBC in bar graph. In the imbedded boxplot, the upper and lower ends of boxes denote the 0.25 and 0.75 percentiles, respectively. The solid line and dot in the box mark the median and mean of each dataset. The open circles denote outliers. Asterisks represent significant differences between grazing and fencing (*$P < 0.05$, **$P < 0.01$).

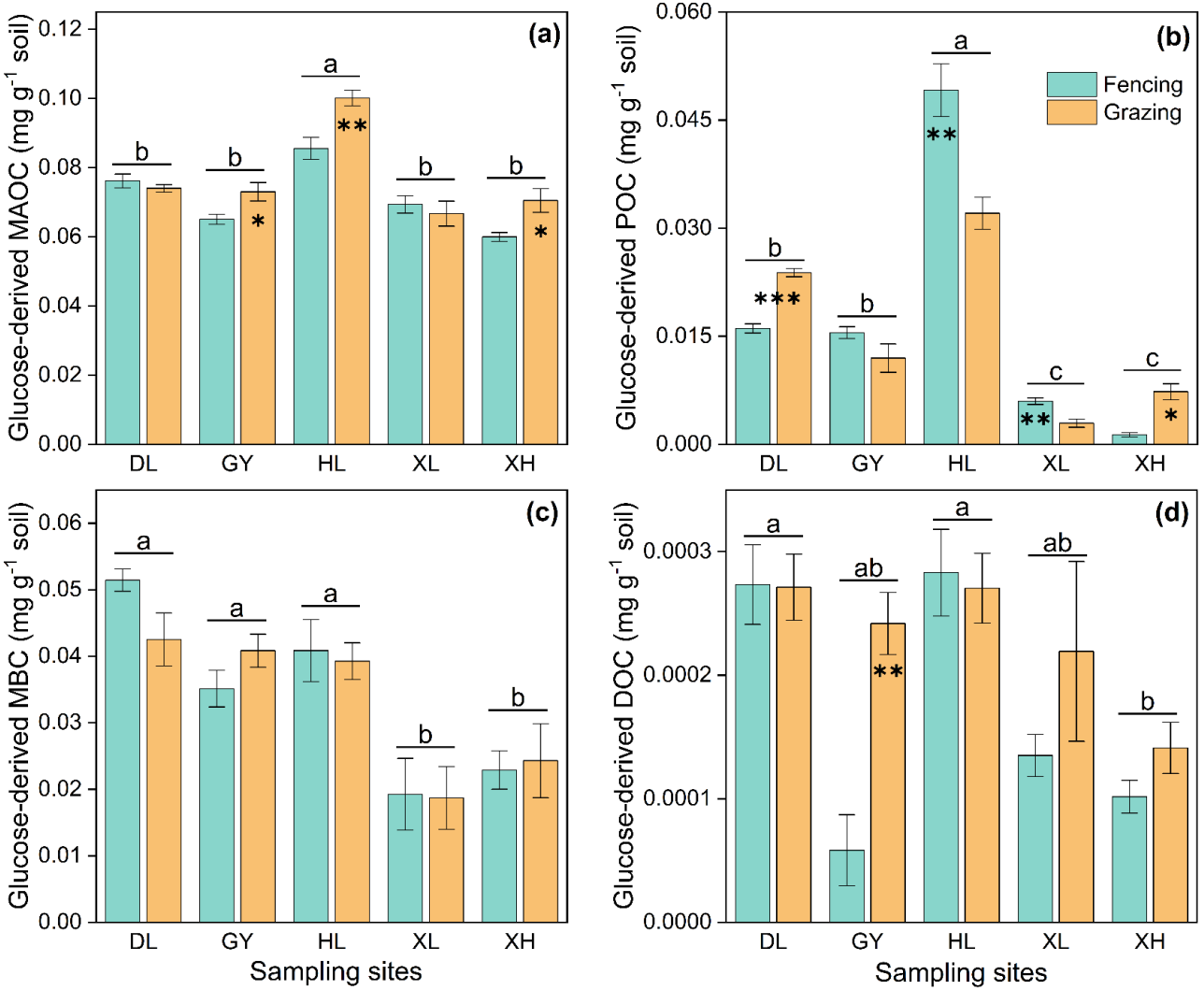

Figure S3. **Response of C sequestration to sites and fencing. a**. Glucose-derived MAOC; **b**. Glucose-derived POC; **c**. Glucose-derived MBC; **d**. Glucose-derived DOC. The data are the means of four replicates and the error bars represent the standard errors of four replicates. Different letters above bars represent significant differences among sites ($P < 0.05$). Asterisks represent significant differences between grazing and fencing treatment (*$P <$ 0.05, **$P < 0.01$, ***$P < 0.001$).

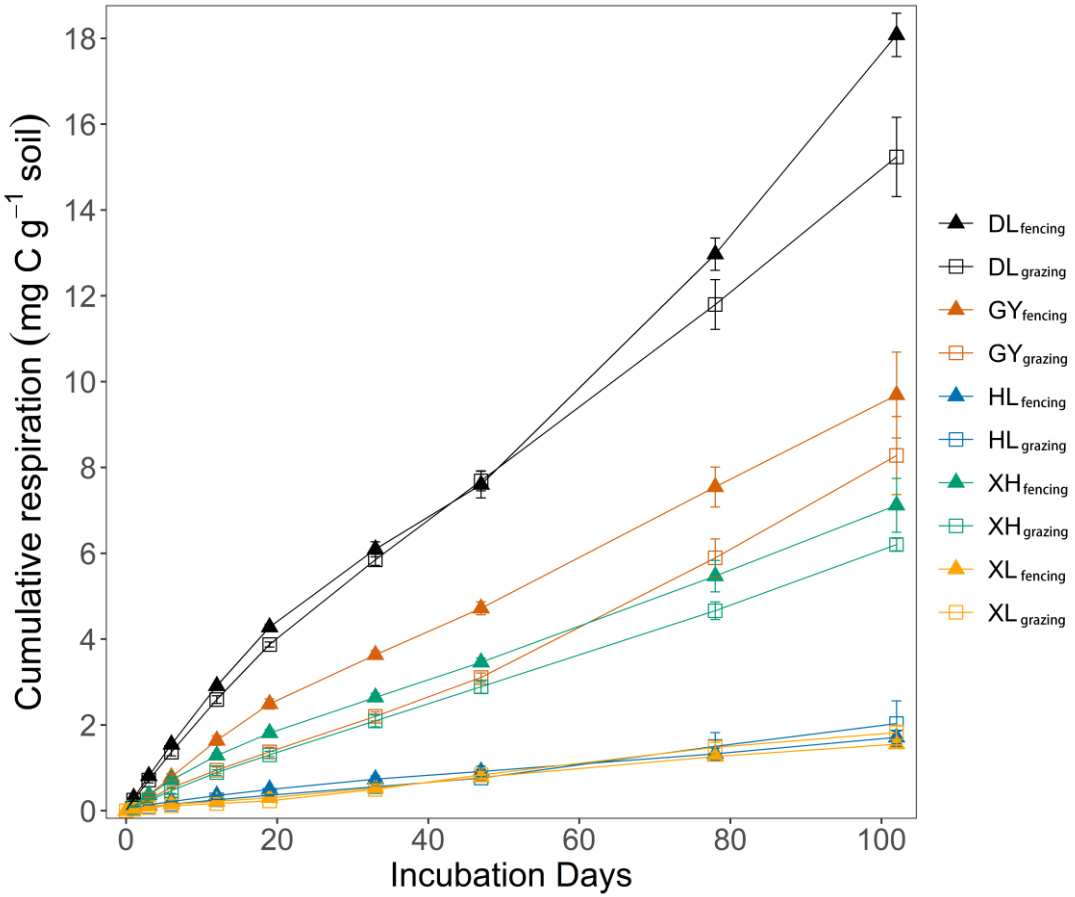

Figure S4. Response of cumulative respiration to sites and fencing. The error bars represent the standard errors of four replicates. Please see Table 1 for the abbreviations.

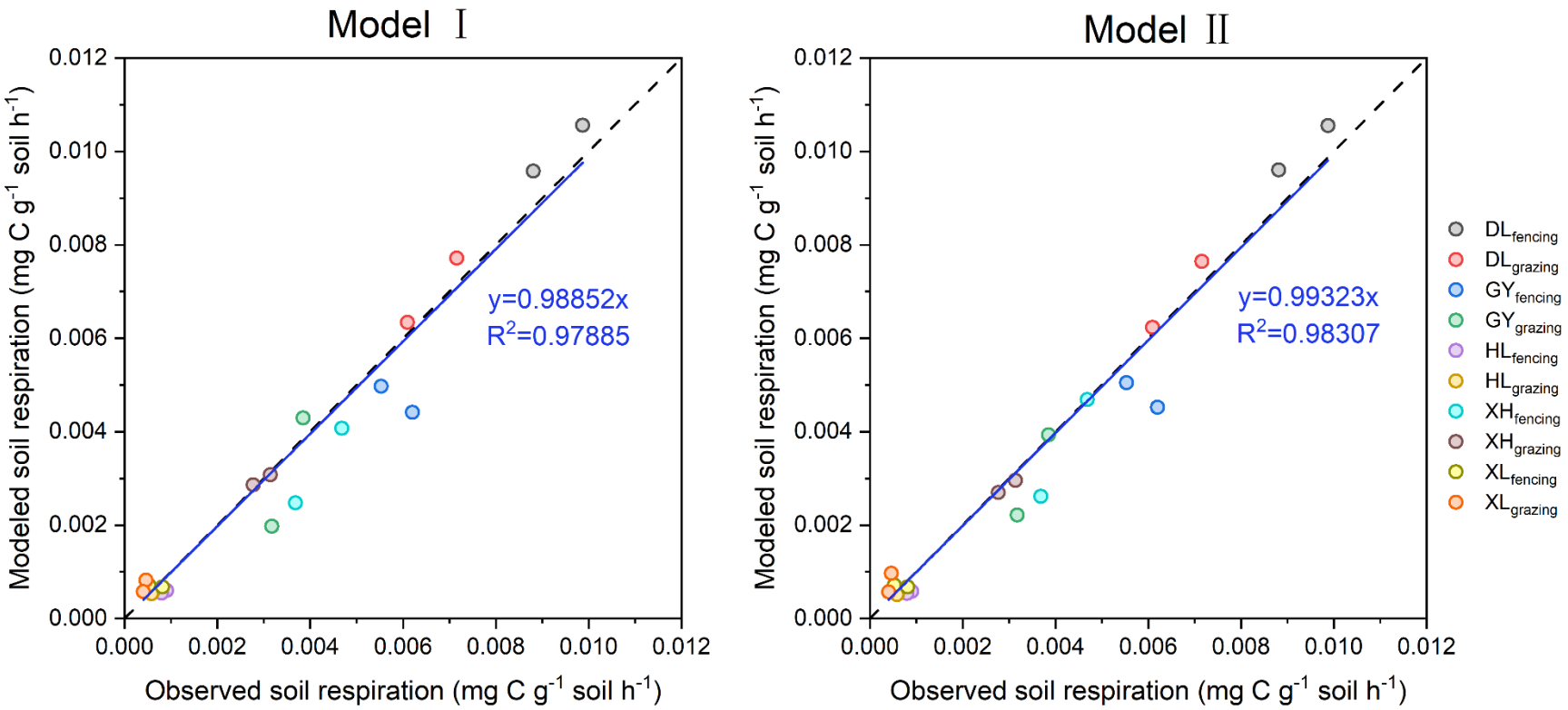

Figure S5. Model validation using soil respiration data. Two randomly selected measurements from CO_2 emission data per site were used for model validation. Diagonal black dotted line is 1:1 line. Please see Table 1 for the abbreviations.

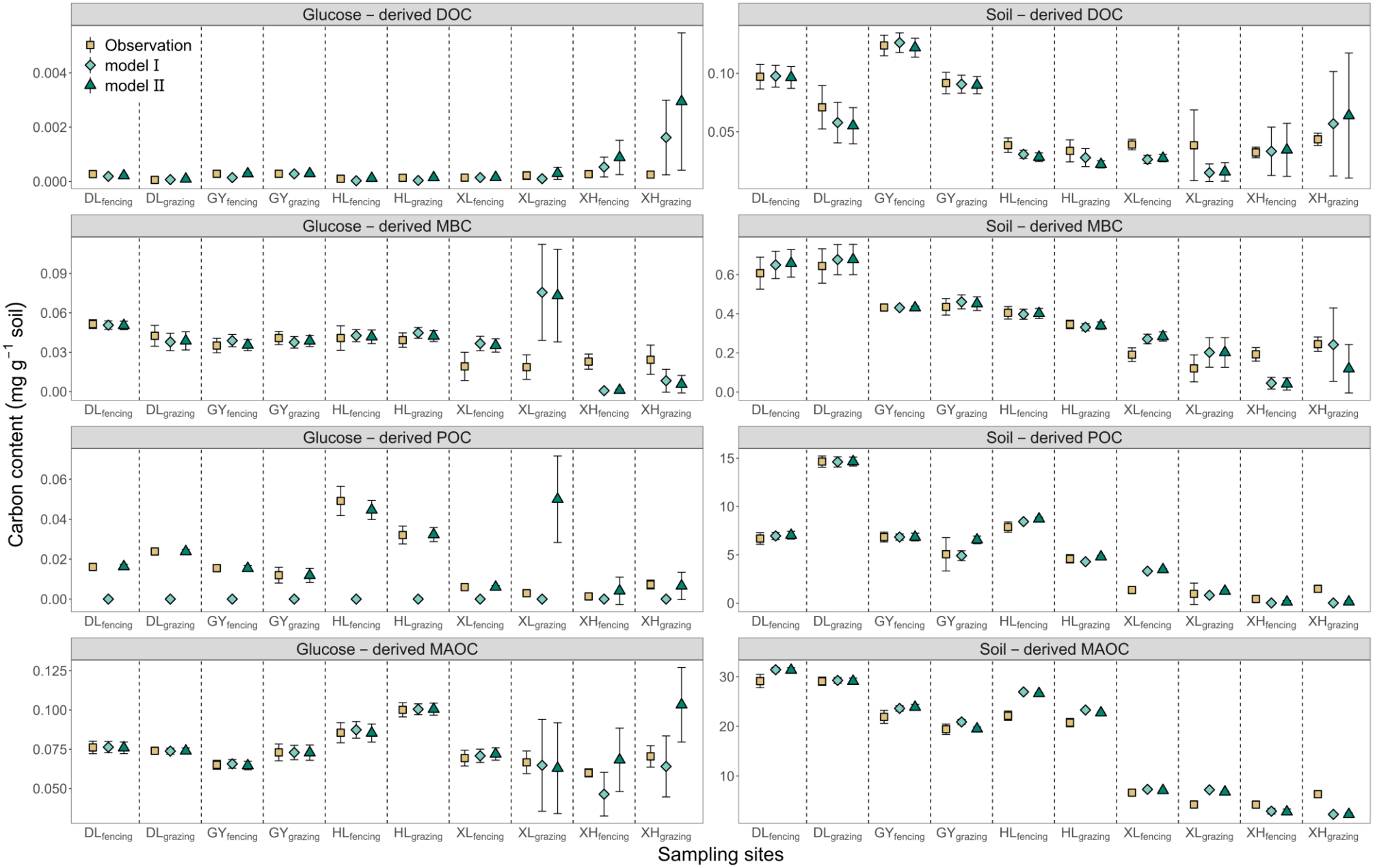

Figure S6. Observed and modeled soil C pools by Model I and II. The error bars represent the standard deviation of each dataset.

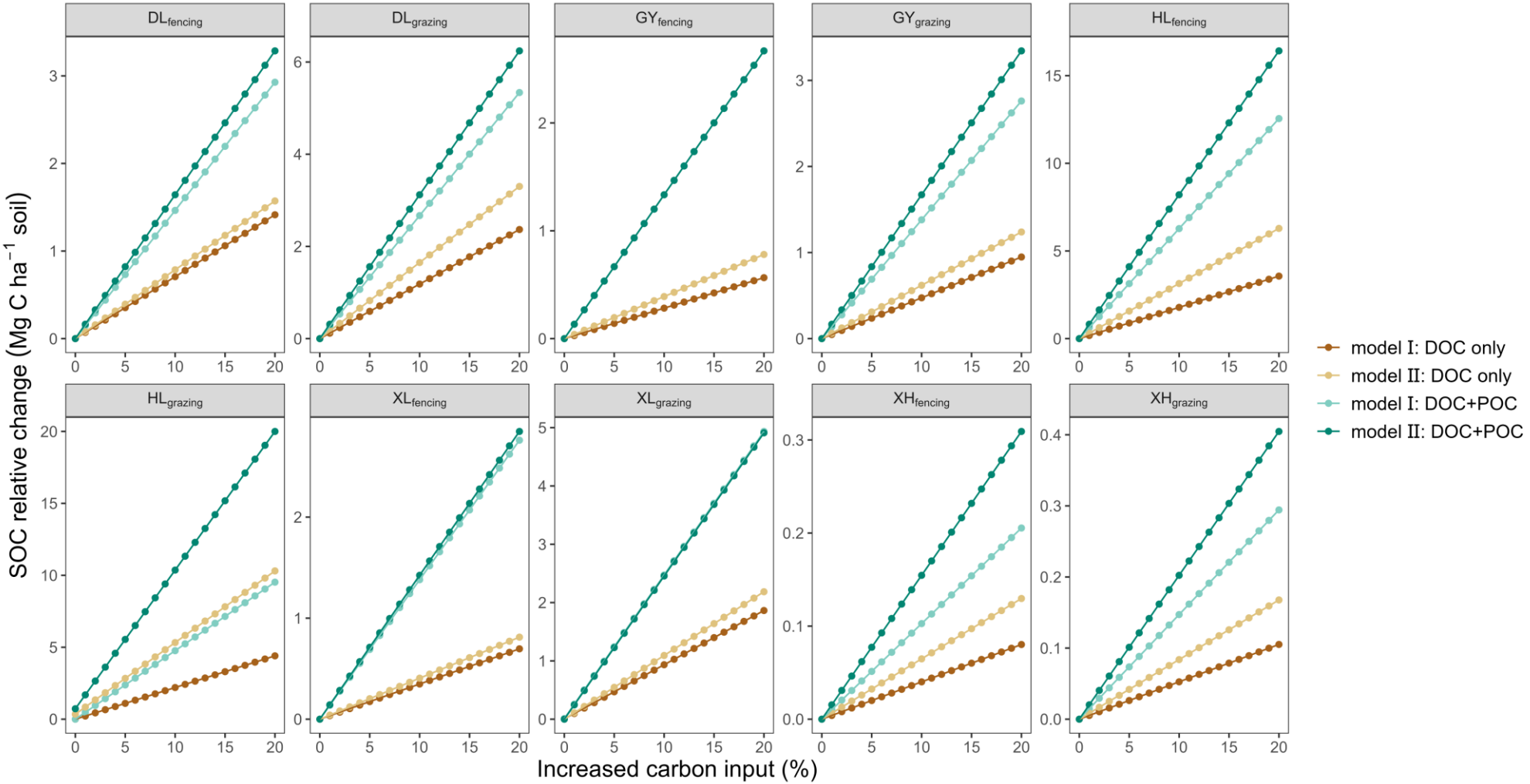

Figure S7. Continuous relative changes in the steady state along a gradient of C input increase under two types of C input conditions. C input increase from 1% to 20% with a 1% interval.

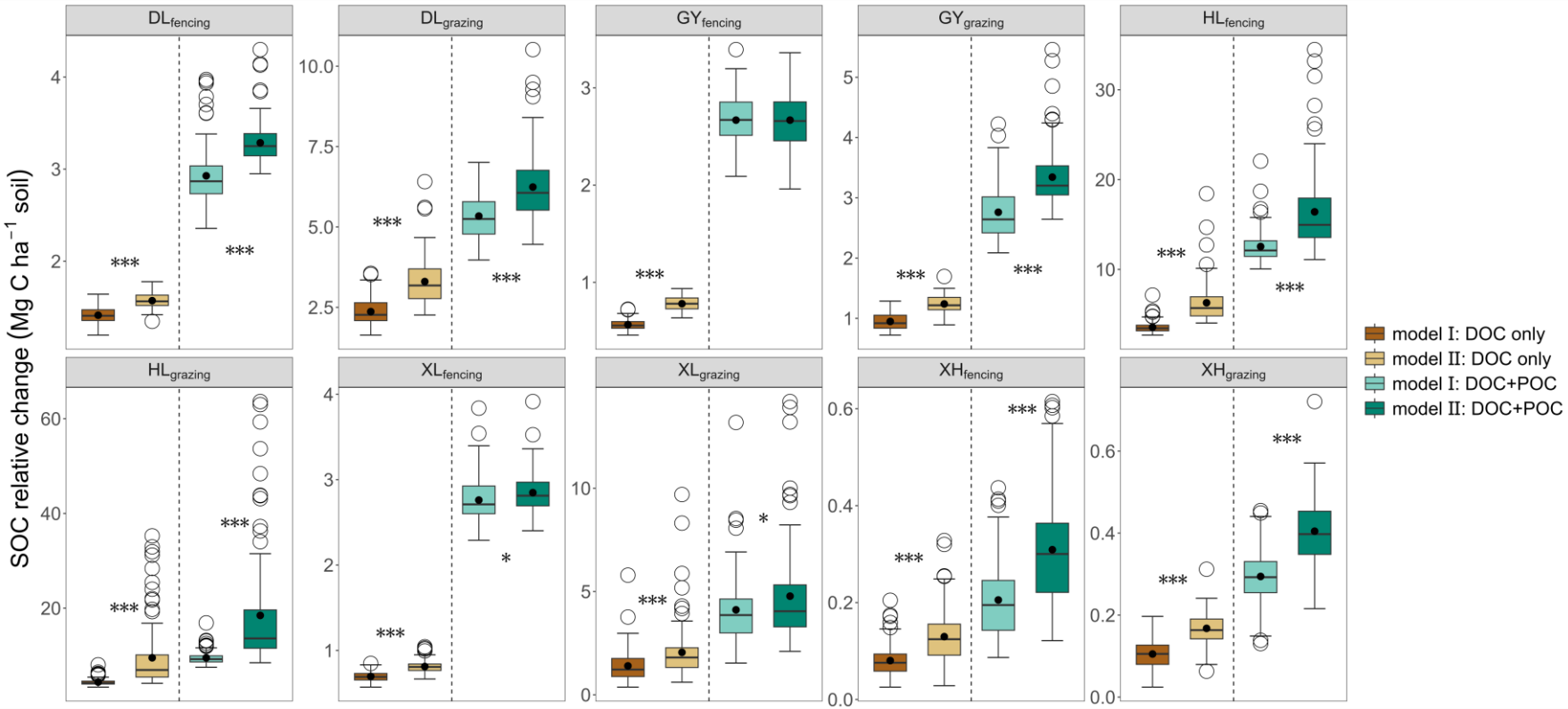

Figure S8. Relative changes in steady state at 20% C input increase under two types of C input conditions. The upper and lower ends of boxes denote the 0.25 and 0.75 percentiles, respectively. The solid line and dot in the box mark the median and mean of each dataset. The open circles denote outliers. Asterisks represent significant differences between Model I and Model II (*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$).