

1 **Supplementary Information for**
2 **Microbial turnover mediates nonlinear response of soil N₂O and CH₄ fluxes to**
3 **diversity loss**

4 **Running title:** soil N₂O and CH₄ fluxes respond to diversity loss

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28 **This file includes supplementary figures and tables.**

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30 **Supporting information**

31 **Fig. S1.** Overview of study locations. Three sites (forest, grassland, and cropland)
32 were selected. At each site, four plots were established, and soil samples were
33 collected from 0-10 cm depth after removing the litter layer.

34 **Fig. S2.** Bacterial and fungal diversity at each site along the microbial diversity
35 dilution gradient were assessed by high-throughput sequencing at the end of the
36 incubation.

37 **Fig. S3.** (A) Microbial biomass carbon and (B) nitrogen across microbial diversity
38 dilution treatments at each site.

39 **Fig. S4.** Effects of microbial diversity dilution treatments on microbial community
40 physiological traits at each study site. Linear mixed-effect models show that dilution
41 treatments significantly alter microbial (A) turnover rate, (B) GNM, (C) CUE and (D)
42 NUE.

43 **Fig. S5.** Correlation between soil N₂O and CH₄ fluxes and microbial community
44 physiological traits. Significance levels: *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

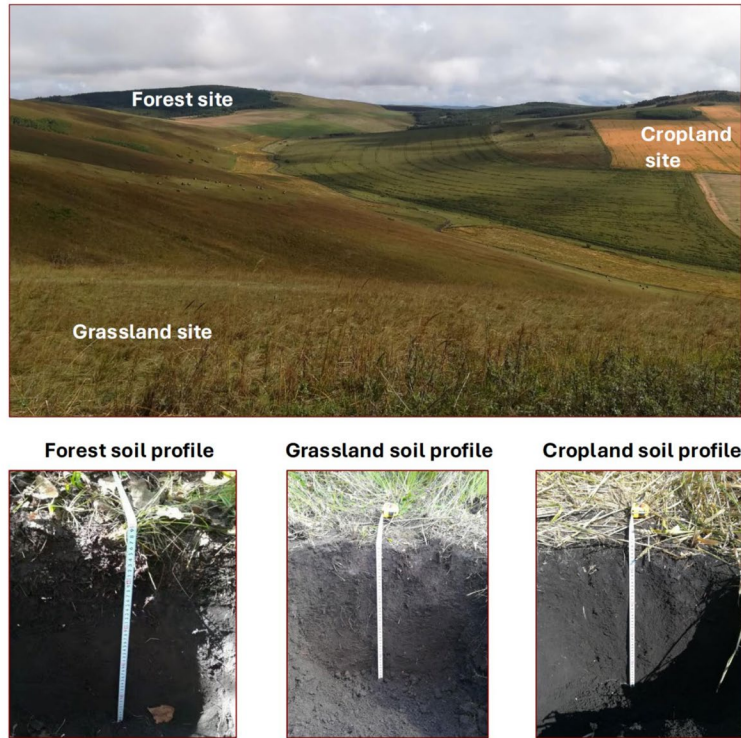
45 **Fig. S6.** Genus-level random forest analysis of microbial community composition in
46 predicting soil N₂O and CH₄ fluxes. Variable importance plots for (A) N₂O and (B)
47 CH₄ flux, with fifteen microbial genera used as predictor variables. The legend
48 indicates the phylum of each corresponding genus.

49 **Fig. S7.** Effects of dilution treatments on microbial community composition. Soil

50 bacterial (A, C and E) and fungal (B, D and F) composition at phyla level were
51 significantly altered across the dilution gradients at forest site (A, B), grassland site
52 (C, D), and cropland site (E, F).

53 **Table S1. Basic information for the studied sites (mean \pm SD, n = 4).** WHC, soil
54 water holding capacity; pH, soil pH; SOC, soil organic carbon; TN, soil total nitrogen;
55 $\delta^{13}\text{C}$, soil ^{13}C natural abundance; $\delta^{15}\text{N}$, soil ^{15}N natural abundance.

56 **Table S2. Final linear mixed-effect models for predicting soil N_2O and CH_4 fluxes**
57 **(comparison of linear and squared models).** Models were selected by a stepwise
58 procedure guided by variance inflation factors (VIFs) and the Akaike Information
59 Criterion (AIC). Predictors with ‘—’ were excluded from the final model due to
60 collinearity (VIF > 10) or because they did not improve model fit (AIC). Significant
61 ($p < 0.05$) coefficients are shown in bold. SD, standard deviation.

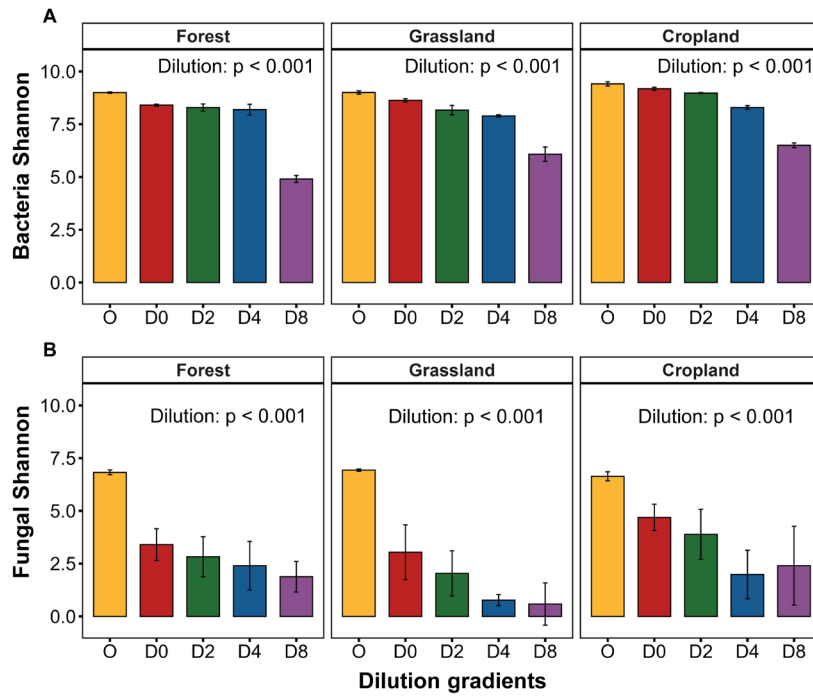


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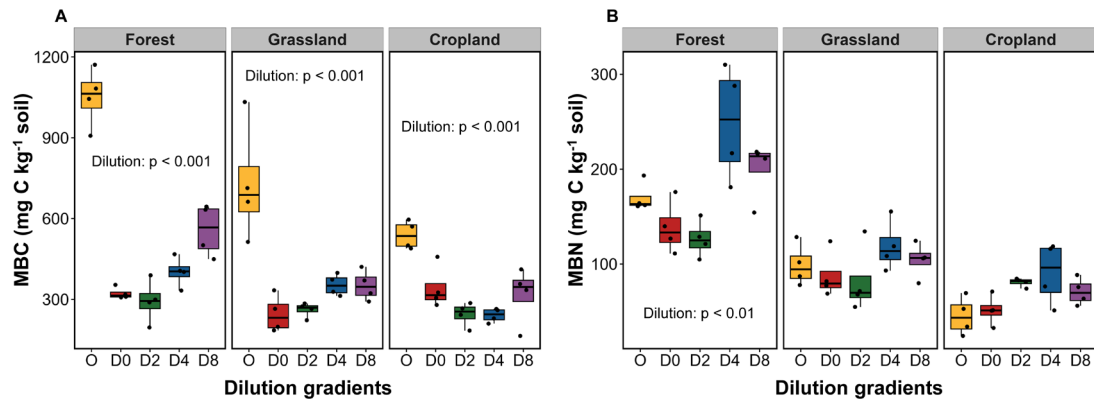


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68 dilution gradient were assessed by high-throughput sequencing at the end of the

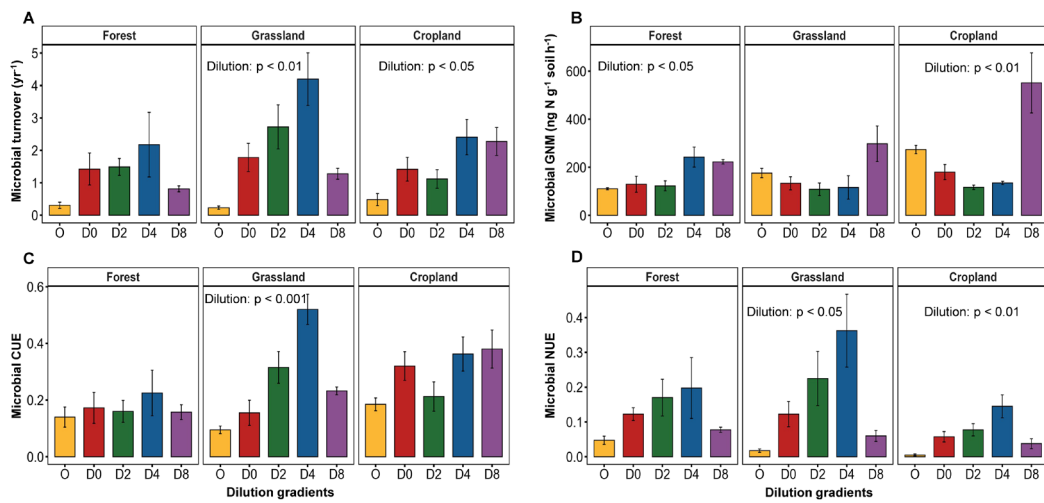
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72 dilution treatments at each site.



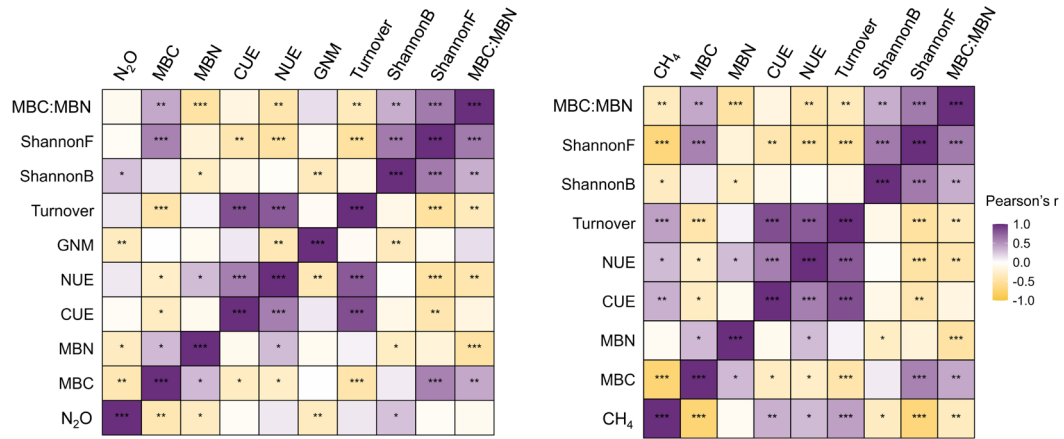
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75 physiological traits at each study site. Linear mixed-effect models show that dilution

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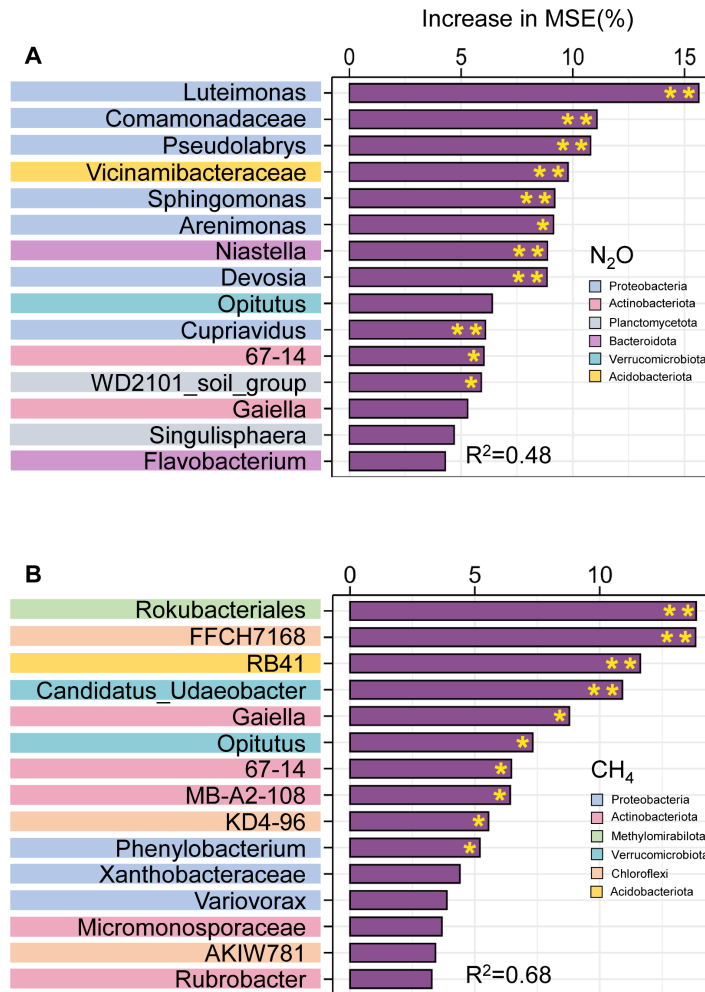


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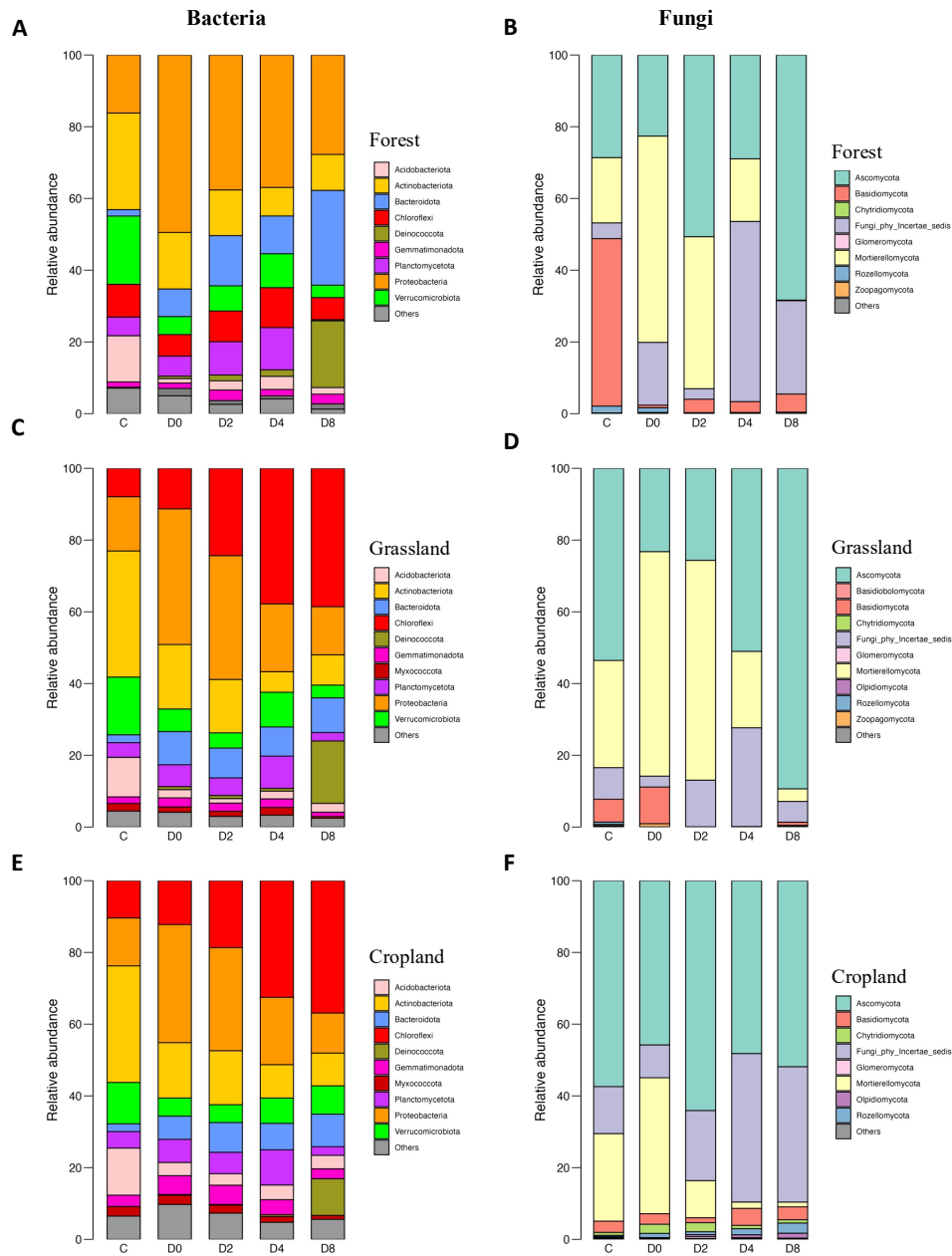
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Site	Latitude	Longitude	Altitude	WHC	pH	SOC	TN	$\delta^{13}\text{C}$	$\delta^{15}\text{N}$
name	(°N)	(°E)	(m)	(%)		(%)	(%)	(‰)	(‰)
Forest	120.29	50.29	742.00	54.2 \pm 1.0	6.00 \pm 0.02	9.90 \pm 0.29	9.90 \pm 0.20	-26.60 \pm 0.05	5.41 \pm 0.33
Grassland	123.28	50.28	697.00	40.8 \pm 1.0	6.40 \pm 0.05	4.40 \pm 0.10	4.40 \pm 0.10	-25.80 \pm 0.05	6.76 \pm 0.28
Cropland	120.28	50.28	651.00	38.6 \pm 0.7	6.40 \pm 0.03	4.80 \pm 0.10	4.80 \pm 0.10	-26.60 \pm 0.02	6.84 \pm 0.73

95 **Table S2. Final linear mixed-effect models for predicting soil N₂O and CH₄ fluxes (comparison of linear and squared models).** Models
96 were selected by a stepwise procedure guided by variance inflation factors (VIFs) and the Akaike Information Criterion (AIC). Predictors with
97 ‘—’ were excluded from the final model due to collinearity (VIF > 10) or because they did not improve model fit (AIC). Significant ($p < 0.05$)
98 coefficients are shown in bold. SD, standard deviation.

Predictors	N ₂ O		N ₂ O		CH ₄		CH ₄	
	linear terms		squared terms		linear terms		squared terms	
	Estimates±SD	VIF	Estimates±SD	VIF	Estimates±SD	VIF	Estimates±SD	VIF
Intercept	5.32±0.19	—	5.09±0.29	—	6.59±0.13	—	6.56±0.09	—
ShannonB	1.00±0.20	2.17	2.71±1.89	230.03	—	—	—	—
ShannonF	-0.54±0.24	2.93	1.93±0.68	29.82	-0.24±0.05	1.48	0.29±0.19	21.39
Turnover	0.88±0.35	6.42	0.14±0.38	9.08	0.22±0.10	5.12	0.04±0.11	7.00
NUE	-0.10±0.34	5.89	-0.15±0.32	6.24	—	—	—	—
CUE	-0.31±0.28	3.88	-0.07±0.29	4.96	-0.11±0.09	4.19	-0.01±0.09	4.49
GNM	-0.48±0.18	1.76	-0.54±0.17	1.86	—	—	—	—
Turnover×NUE	-0.40±0.14	2.97	-0.10±0.15	4.13	—	—	—	—
Turnover×CUE	—	—	—	—	-0.07±0.04	2.07	-0.02±0.04	2.46
ShannonB ²	—	—	-1.98±2.00	255.26	—	—	—	—
ShannonF ²	—	—	-2.47±0.67	29.76	—	—	-0.57±0.20	24.01
AIC	202.25		189.79		67.03		62.77	
Conditional R ²	0.54		0.65		0.57		0.56	