

Supplementary material for

Soil nutrient variation along a shallow catena in Paracou, French Guiana

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Text S1. Enzyme extraction

Extracellular acid phosphatase activity in soil was determined colorimetrically in both seasons in the 0-15 and 15-30 cm soil layers using p-Nitrophenylphosphate substrate, as described in Peguero et al. (2019). Enzyme activity was expressed as $\mu\text{mole of pNP g}^{-1} \text{ soil DW h}^{-1}$.

Reference

Peguero, G, Sardans, J, Asensio, D, Fernández-Martínez, M, Gargallo-Garriga, A, Grau, O, Llusà, J, Margalef, O, Márquez, L, Ogaya, R, Urbina, I, Courtois, EA, Stahl, C, Van Langenhove, L, Verryckt, LT, Richter, A, Janssens, IA, Peñuelas, J (2019) Nutrient scarcity strengthens soil fauna control over leaf litter decomposition in tropical rainforests. *Proceedings of the Royal Society B: Biological Sciences* 286 (1910), 20191300. doi:10.1098/rspb.2019.1300

Supplementary Figures

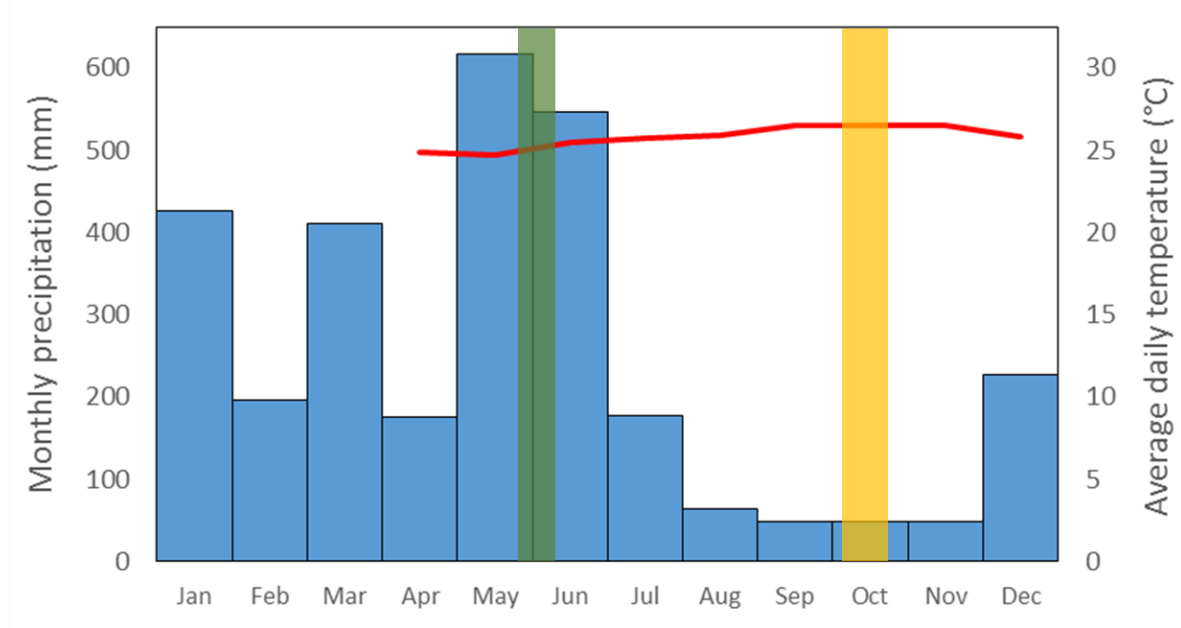


Figure S1 Climate graph for Paracou, 2015. Monthly precipitation (measured with rainfall gauge above the canopy) is shown by blue bars. The red line shows the average daily air temperature. The green bar indicates the wet season sampling period (May 29th – June 10th) and the yellow line indicates the dry season sampling period (October 5th – October 21st). Combined precipitation during the wet season was 2777.4 mm and combined precipitation during the dry season was 209.4 mm. Precipitation and average temperature during the sampling in the wet season was 476 mm and 25.3 °C, respectively. Precipitation and average temperature during the sampling in the dry season was 24 mm and 26.5 °C, respectively.

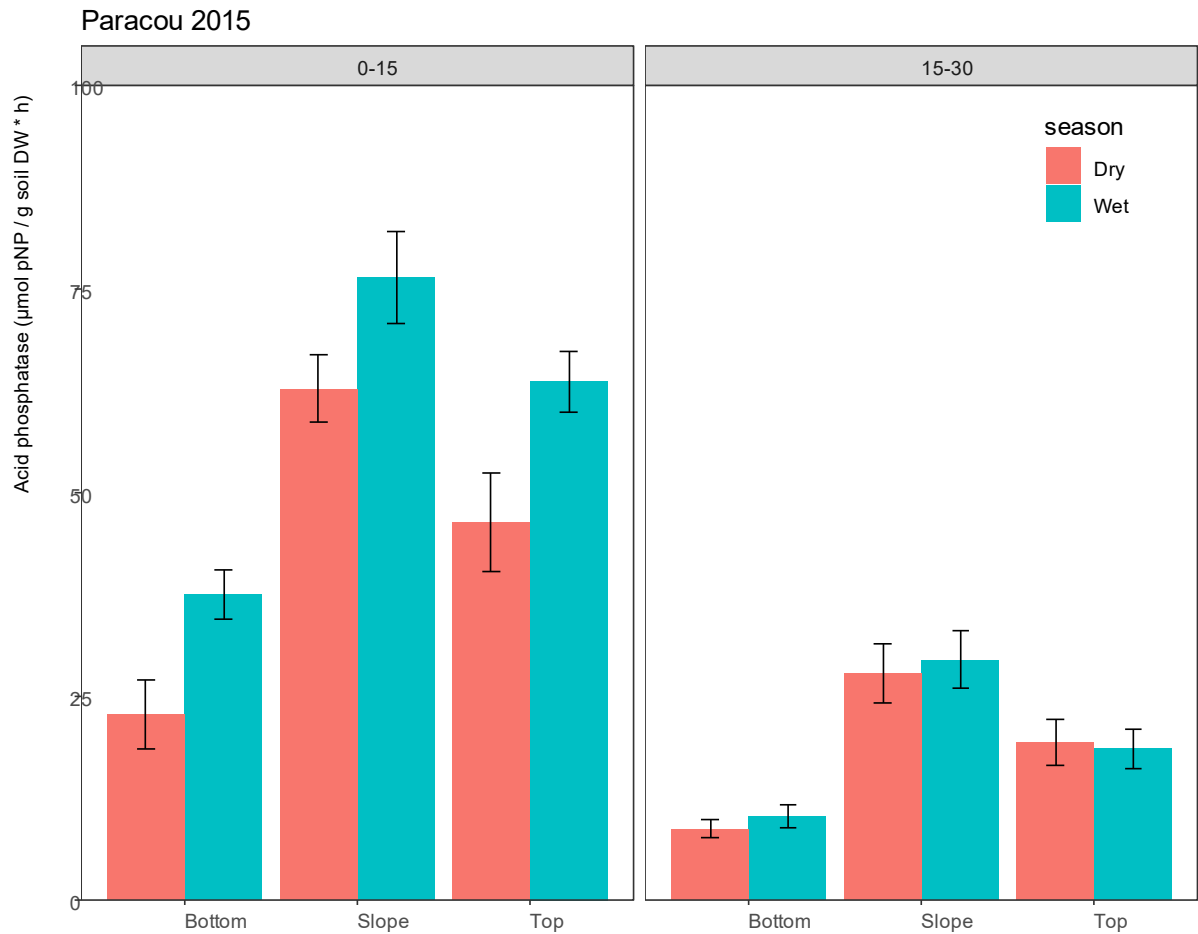


Figure S2 Acid phosphatase (ACP) activity in Paracou soils for a depth of 0-15 cm (left) and 15-30 cm (right). Activity during the dry season (red bars) and wet season (blue bars) is shown for the three sampled topographic units (bottom, slope and top). Error bars represent standard errors and N is 20 for each bar. In the upper soil layer (0-15 cm) there is a constant significant (t.test, $P < 0.001$) difference between wet and dry season with higher activities occurring during the wet season. Regarding topographic differences, in both soil depths the ACP activities on the slopes were significantly higher than on the tops, which were in turn significantly higher than on the bottom (lm, $P < 0.001$ for all).

Supplementary Tables

Table S1 We used X-ray diffraction (XRD) followed by database matching to identify the common minerals found in the sampled soils. The qualitative mineral phase analysis was performed with the aid of the Powder Diffraction File Data base PDF-4+ 2020 (ICDD, 2016) and through the X'Pert HighScore Plus software, version 4.7, 2017 (Degen et al., 2014). These are the reference numbers used for the identification of each of the different minerals.

Mineral	Reference number
Quartz	00-046-1045
Gibbsite	00-033-001
Goethite	01-074-2195
Hematites	00-033-0664
Kaolinite	01-089-6538
	01-078-2109
Nacrite	00-034-0170
	01-076-1781
Lizardite	01-072-1500
Anatase	01-071-1169
Diaspore	01-072-1268
Microcline	01-084-0708
Rutile	01-076-1939

Table S2 Linear Pearson correlation coefficients between percentages of clay and silt particles, macro nutrients, micro nutrients and trace metals in soils sampled at two depths. Within depth, no distinction between season was made. Statistically significant correlations ($P < 0.05$) are marked with an asterisk (*). Correlations significant at level $P < 0.01$ are marked with ** and correlation significant at level $P < 0.001$ are marked with ***. $N = 10$ per plot and per depth (five measures taken in each season)

	Clay	Silt	Pb	Sr	As	Cr	V	Ni	Zn	Mn	Cu	Mo	Fe	Mg	K	P	N
Depth 0-15 cm																	
C	0.45***	0.48***	0.28**	0.12	0.07	0.04	0.02	0.18	0.31***	0.13	0.13	-0.10	-0.03	0.09	0.18*	0.35***	0.92***
N	0.49***	0.51***	0.38***	0.15	0.01	-0.07	-0.08	0.09	0.28**	0.06	0.10	-0.11	-0.11	0.02	0.20*	0.39***	
P	0.67***	0.60***	0.61***	0.54***	0.51***	0.35***	0.41***	0.24**	0.26**	-0.02	0.34***	0.10	0.39***	-0.21*	0.19*		
K	0.28**	0.31**	0.11	0.10	0.28**	0.36***	0.35***	0.42***	0.14	0.38***	0.43***	0.13	0.34***	0.19*			
Mg	-0.04	0.01	-0.04	0.10	0.02	0.27**	0.15	0.07	0.10	0.37***	0.14	-0.06	0.16				
Fe	0.23	0.21*	0.05	0.17	0.90***	0.91***	0.98***	0.43***	0.35***	0.47***	0.70***	0.34***					
Mo	0.13	0.11	0.05	0.03	0.35***	0.39***	0.35***	0.79***	0.17	0.11	0.28**						
Cu	0.34***	0.35***	0.16	0.25**	0.63***	0.73***	0.68***	0.44***	0.49***	0.45***							
Mn	0.17	0.17	-0.02	-0.01	0.33***	0.53***	0.48***	0.44***	0.30**								
Zn	0.33***	0.39***	0.22*	0.17	0.33***	0.36***	0.35***	0.35***									
Ni	0.35***	0.36***	0.12	0.05	0.38***	0.53***	0.47***										
V	0.24**	0.22*	0.04	0.17	0.91***	0.93***											
Cr	0.22*	0.22*	0.01	0.21*	0.84***												
As	0.38***	0.31***	0.22*	0.25**													
Sr	0.30**	0.18*	0.64***														
Pb	0.68***	0.63***															
Silt	0.89***																
Depth 15 – 30 cm																	
C	0.54***	0.53***	0.55***	0.04	0.19*	0.20*	0.12	0.25**	0.09	-0.02	0.33***	0.20*	0.04	0.03	0.02	0.59***	0.97***
N	0.58***	0.56***	0.62***	0.05	0.14	0.12	0.05	0.25**	0.05	-0.07	0.23*	0.20*	-0.05	-0.02	0.01	0.64***	
P	0.49***	0.56***	0.60***	0.41***	0.48***	0.28**	0.27**	0.15	0.10	-0.05	0.36***	0.20*	0.23*	-0.13	0.03		

Table S3 PCA results: Eigenvalues and associated proportion of variance explained by the first 5 principal components (PC)

	PC 1	PC 2	PC 3	PC 4	PC 5
Depth 0 – 15 cm					
Eigenvalues	5.91	2.70	1.72	1.37	1.08
Proportion of Variance explained (%)	36.9	16.9	10.8	8.5	6.7
Cumul explained	36.9	53.8	64.6	73.1	79.8
Depth 15 – 30 cm					
Eigenvalues	5,62	2.97	1.62	1.27	1.03
Proportion of Variance explained (%)	35.1	18.5	10.1	7.9	6.5
Cumul explained	35.1	53.6	63.7	71.6	78.1

Table S4 PCA result: Factor matrix displaying the factor loadings of each variable on components one and two. Loadings > 0.55 are in bold and were considered to correlate well with the corresponding principal component.

	Depth 0 – 15 cm			Depth 15 – 30 cm	
	PC 1	PC 2		PC 1	PC 2
C	0.21	0.75		0.40	0.75
N	0.14	0.83		0.34	0.82
P	0.53	0.58		0.52	0.62
K	0.49	0.06		0.38	0.15
Mg	0.20	0.12		0.10	0.14
Fe	0.90	0.27		0.88	0.37
Mo	0.46	0.24		0.38	0.24
Cu	0.81	0.03		0.86	0.04
Mn	0.56	0.19		0.61	0.35
Zn	0.52	0.25		0.59	0.20
Ni	0.66	0.07		0.49	0.19
V	0.91	0.25		0.92	0.31
Cr	0.91	0.26		0.91	0.23
As	0.86	0.09		0.86	0.11
Sr	0.33	0.49		0.30	0.11
Pb	0.27	0.70		0.34	0.68

Table S5 Squared factor loadings for each of the variables at both soil depths. Factor loadings above 0.3 were considered important (bold font).

Variable	0 – 15 cm depth		15 – 30 cm depth	
	PC1	PC2	PC1	PC2
C	0.045	0.556	0.150	0.624
N	0.020	0.687	0.108	0.743
P	0.281	0.357	0.253	0.418
K	0.244	0.004	0.138	0.025
Mg	0.039	0.014	0.009	0.022
Fe	0.807	0.072	0.728	0.148
Mo	0.214	0.055	0.138	0.066
Cu	0.650	0.001	0.695	0.001
Mn	0.317	0.036	0.349	0.135
Zn	0.272	0.060	0.335	0.043
Ni	0.432	0.005	0.231	0.041
V	0.828	0.063	0.798	0.108
Cr	0.834	0.066	0.789	0.060
As	0.748	0.008	0.704	0.013
Sr	0.109	0.237	0.083	0.014
Pb	0.070	0.495	0.108	0.508

Table S6 Soil C, N and $\delta^{15}\text{N}$ values at the three landscape positions.

	Wet	Wet	Wet	Dry	Dry	Dry
Properties	Bottom	Slope	Top	Bottom	Slope	Top
Soil C (%)	1.72 ^a (0.12)	2.30 ^a (0.13)	1.86 ^a (0.11)	2.48 ^b (0.12)	2.63 ^b (0.15)	2.13 ^b (0.1)
Soil N (%)	0.13 ^a (0.01)	0.16 ^a (0.01)	0.14 ^a (0.01)	0.17 ^b (0.01)	0.18 ^b (0.01)	0.15 ^b (0.01)
$\delta^{15}\text{N}$ (‰)	5.56 ^a (0.3)	5.77 ^a (0.26)	4.84 ^b (0.17)	5.84 ^a (0.15)	5.44 ^a (0.13)	4.54 ^b (0.10)
Soil P (mg kg ⁻¹)	80.83 ^a (3.16)	116.74 ^b (6.9)	75.66 ^a (7.87)	88.96 ^c (3.03)	139.38 ^d (6.98)	75.21 ^c (3.3)
Soil C:N	13.27 ^a (0.37)	14.09 ^a (0.21)	13.69 ^a (0.21)	14.43 ^b (0.23)	14.58 ^b (0.4)	14.8 ^b (0.68)
Soil C:N:P	232 (21) : 17.1 (1.3) : 1	209 (16) : 14.7 (1.0) : 1	278 (21) : 20.4 (1.5) : 1	293 (16) : 20.3 (1.1) : 1	201 (18) : 13.6 (0.8) : 1	302 (18) : 20.3 (0.9) : 1
C stock (kg m ⁻²)						
0-15 cm	3.27 ^a (0.22)	3.66 ^a (0.20)	2.76 ^b (0.20)	4.7 ^c (0.25)	4.16 ^c (0.25)	3.25 ^a (0.22)
15-30 cm	1.75 ^a (0.18)	1.75 ^a (0.01)	1.20 ^b (0.06)	2.07 ^c (0.18)	2.13 ^c (0.15)	1.41 ^d (0.08)
N stock (kg m ⁻²)						
0-15 cm	0.24 ^a (0.01)	0.26 ^a (0.01)	0.20 ^b (0.01)	0.33 ^c (0.02)	0.29 ^c (0.01)	0.22 ^a (0.01)
15-30 cm	0.14 ^a (0.01)	0.14 ^a (0.01)	0.10 ^b (0.01)	0.16 ^c (0.01)	0.16 ^c (0.01)	0.11 ^d (0.01)
P stock (g m ⁻²)						
0-15 cm	15.70 ^{ab} (0.72)	19.10 ^a (1.31)	11.31 ^b (1.00)	16.82 ^{ab} (0.71)	21.91 ^a (0.82)	11.21 ^b (0.60)
15-30 cm	14.44 ^a (1.16)	16.43 ^a (0.74)	11.85 ^a (0.80)	17.75 ^a (1.09)	17.85 ^a (0.98)	10.87 ^a (0.86)

Notes: Values are means, with SE in parentheses, and different subscripted letters indicate significant ($\alpha = 0.05$) differences between topographical positions and seasons according to LMER models. Concentrations and $\delta^{15}\text{N}$ values are for surface soils, 0-15 cm depth, stocks are taken at two soil depths