Biogeochemistry

Supplementary material for:

Soil greenhouse gas fluxes following conventional and reduced-impact selective logging in a Congo Basin rainforest

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Text S1 Soil sampling and analysis

Soil samples were taken from 12 randomly selected sampling points and mixed thoroughly to have one composite sample for each stratum (i.e., felling gap, skidding trail, logging deck, road, and undisturbed reference area) within each replicate plot (Fig. S1). Soil sampling was conducted between July and September 2016. Soil samples were taken at three depth intervals down to 50 cm, and we report in Table S1 the values for the top depth interval (0–10 cm). The soil samples were air-dried, sieved through 2-mm sieve, transported by air to Germany, and dried again at 40°C prior to analysis in the laboratory. Soil bulk density was determined using the core method (average of three measurements for each stratum in each replicate plot). Soil pH was measured from a 1:2.5 soil-to-distilled water ratio. Effective cation exchange capacity (ECEC) was determined by percolation with unbuffered 1 mol L^{-1} NH4Cl and the exchanged cation concentrations (Mg, Ca, K, Na, Al, Fe, Mn) in percolates were measured using inductively coupled plasma – atomic emission spectrometer (ICP-AES; iCAP 6300 Duo VIEW ICP Spectrometer, Thermo Fischer Scientific GmbH, Dreieich, Germany). Base and Al saturations were calculated, respectively, as the percentage exchangeable bases (Mg, Ca, K and Na) and Al on ECEC. Subsamples of the composited soil samples were finely ground for measurement of total organic C, total N (using a CN analyser; Vario EL Cube, Elementar Analysis Systems GmbH, Hanau, Germany) and ^{15}N natural abundance signature (using isotope ratio mass spectrometry; Delta Plus, Finnigan MAT, Bremen, Germany). Phosphorus was extracted using the Bray 2 method and analyzed using the above-described ICP-AES.

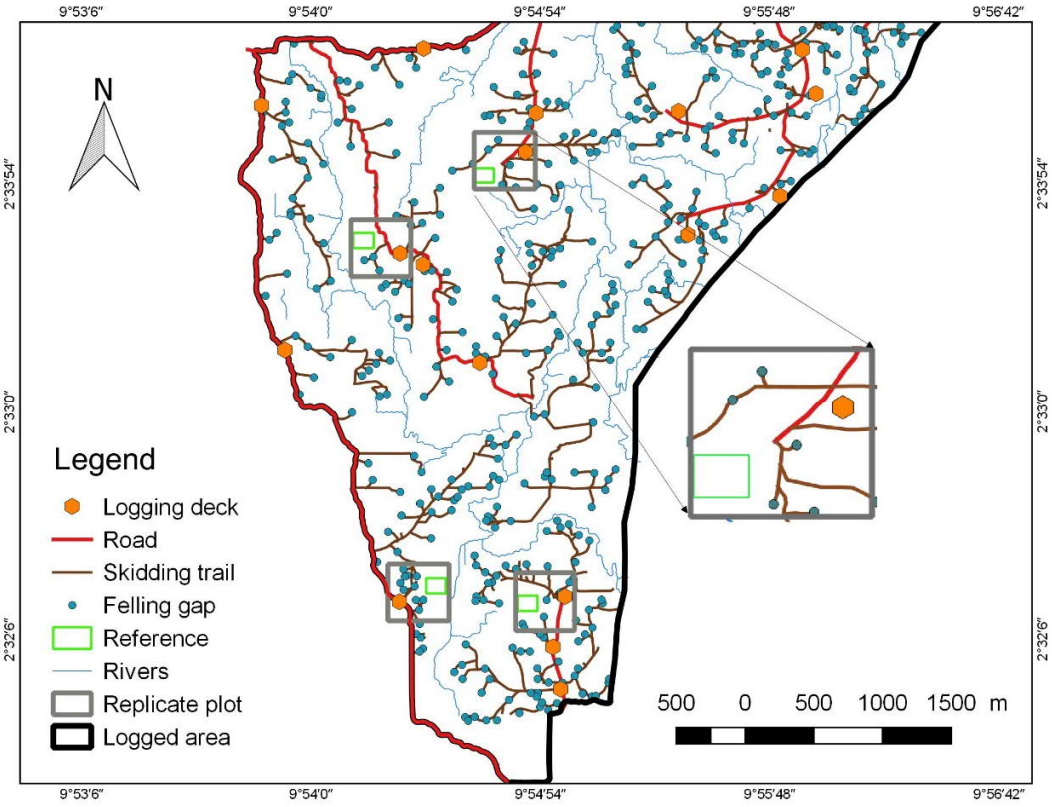

Fig. S1 Map illustrating the experimental design at the reduced-impact logging site. Each of the four replicate plots (inset) encompassed the four disturbed strata (road, logging deck, skidding trail, and felling gap) and a corresponding undisturbed reference area, which was separated by at least 50 m distance from any disturbed stratum (Tchiofo Lontsi et al. 2019)

Table S1 Soil physical and biochemical characteristics in the top 10-cm depth for the undisturbed reference area and disturbed strata within each logging system in a Congo Basin rainforest of Cameroun

Logging system	Reference	Felling gap	Skidding trail	Logging deck	Road
Conventional					
Bulk density (g cm^{-3})	1.0 ± 0.0^{b}	1.0 ± 0.0^{b}	1.3 ± 0.0^{a,A}	1.4 ± 0.1^{a}	1.4 ± 0.1^{a}
pH (1:2.5 H_2O)	3.9 ± 0.1^{c,B}	3.9 ± 0.1^{c,B}	4.4 ± 0.1^{b}	4.7 ± 0.1^{a}	4.7 ± 0.1^{a,B}
ECEC (cmolc kg^{-1})	2.5 ± 0.1^{a,B}	2.3 ± 0.1^{ab}	1.7 ± 0.3^{abc}	1.5 ± 0.2^{bc}	1.2 ± 0.1^{c}
Base saturation (%)	15.2 ± 1.9^{a}	16.7 ± 4.5^{a}	26.2 ± 7.2^{a}	29.7 ± 6.8^{a}	38.9 ± 5.6^{a}
Aluminum saturation (%)	69.2 ± 2.1^{a}	64.2 ± 6.8^{a}	60.9 ± 6.4^{a}	61.0 ± 6.8^{a}	52.7 ± 4.9^{a}
^{15}N natural abundance (‰)	7.5 ± 0.3^{a,A}	6.8 ± 0.2^{a}	7.3 ± 0.4^{a}	8.0 ± 0.5^{a}	8.1 ± 0.2^{a}
C:N ratio	13.0 ± 0.4^{a}	13.3 ± 0.7^{a}	13.1 ± 0.9^{a}	13.7 ± 1.0^{a}	12.3 ± 0.7^{a}
Soil organic C (kg C m^{-2})	1.7 ± 0.2^{a,B}	1.4 ± 0.1^{ab}	1.2 ± 0.2^{ab}	1.1 ± 0.2^{ab}	0.7 ± 0.0^{b}
Total N (g N m^{-2})	129 ± 13^{a}	108 ± 13^{ab}	89 ± 14^{ab}	77 ± 17^{ab}	62 ± 3^{b}
Bray-extractable P (g P m^{-2})	0.7 ± 0.1^{a}	0.7 ± 0.0^{ab}	0.4 ± 0.1^{bc}	0.3 ± 0.1^{c}	0.3 ± 0.1^{c}
Reduced-impact					
Bulk density (g cm^{-3})	1.0 ± 0.0^{c}	1.0 ± 0.1^{c}	1.2 ± 0.0^{b,B}	1.4 ± 0.1^{a}	1.4 ± 0.0^{a}
pH (1:2.5 H_2O)	4.2 ± 0.1^{b,A}	4.5 ± 0.1^{ab,A}	4.8 ± 0.2^{a}	4.9 ± 0.2^{a}	5.0 ± 0.0^{a,A}
ECEC (cmolc kg^{-1})	3.3 ± 0.2^{a,A}	2.6 ± 0.3^{ab}	2.8 ± 0.3^{ab}	1.9 ± 0.3^{bc}	1.4 ± 0.1^{c}
Base saturation (%)	20.1 ± 4.0^{a}	33.3 ± 7.2^{a}	44.5 ± 8.4^{a}	34.0 ± 8.5^{a}	30.3 ± 4.6^{a}
Aluminum saturation (%)	65.2 ± 5.4^{a}	54.8 ± 7.0^{a}	46.2 ± 6.6^{a}	57.9 ± 7.1^{a}	62.0 ± 4.5^{a}
^{15}N natural abundance (‰)	6.3 ± 0.2^{b,B}	7.1 ± 0.3^{ab}	6.5 ± 0.2^{ab}	7.2 ± 0.3^{ab}	7.6 ± 0.4^{a}
C:N ratio	14.1 ± 0.4^{a}	13.2 ± 0.4^{a}	15.4 ± 1.4^{a}	15.1 ± 1.8^{a}	13.7 ± 1.1^{a}
Soil organic C (kg C m^{-2})	2.4 ± 0.2^{a,A}	1.9 ± 0.2^{ab}	2.1 ± 0.4^{ab}	1.4 ± 0.4^{ab}	0.9 ± 0.1^{b}
Total N (g N m^{-2})	170 ± 17^{a}	146 ± 20^{ab}	134 ± 18^{abc}	84 ± 15^{bc}	67 ± 5^{c}
Bray-extractable P (g P m^{-2})	0.6 ± 0.1^{a}	0.6 ± 0.1^{a}	0.4 ± 0.1^{ab}	0.2 ± 0.1^{b}	0.1 ± 0.0^{b}

Means (± SE, n = 4 plots) within a row followed by different lowercase letters indicate significant differences among strata within each logging system and uppercase letters indicate significant differences between logging systems within a stratum (ANOVA with Fisher's LSD test at $P \leq 0.05$).