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Effects of nitrogen and phosphorus additions on nitrous oxide emission in a nitrogen-rich and two nitrogen-limited tropical forests

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Table S1. Soil properties in different fertilization plots in three study forests.

Treatment	pH	NH_4^+ (mg kg^{-1})	NO_3^- (mg kg^{-1})	$NH_4^+ + NO_3^-$ (mg kg^{-1})	Soil organic C (%)	Microbial biomass C (mg kg^{-1})	Available P (mg kg^{-1})
				Old-growth forest			
C	3.9(0.0)	2.4(0.3)	4.2(0.2)	6.7(0.5)	4.0(0.2)	551.9(38.5)	2.1(0.4)
N	3.9(0.0)	2.4(0.2)	3.7(0.4)	6.0(0.5)	4.5(0.2)	489.3(24.7)	1.5(0.4)
P	4.0(0.0)	2.6(0.2)	3.7(0.4)	6.3(0.4)	4.1(0.3)	463.1(30.8)	1.9(0.2)
NP	3.9(0.0)	2.8(0.2)	3.6(0.5)	6.4(0.5)	4.6(0.2)	456.1(38.4)	2.1(0.2)
				Mixed forest			
C	4.0(0.0)	1.4(0.1)	1.3(0.2)	2.7(0.2)	2.8(0.2)	75.9(7.0)	0.9(0.1)
N	4.1(0.0)	1.6(0.1)	1.0(0.1)	2.6(0.2)	2.6(0.1)	85.8(6.6)	0.7(0.3)
P	4.0(0.0)	1.4(0.1)	1.0(0.1)	2.3(0.2)	3.0(0.2)	75.7(5.1)	0.8(0.2)
NP	4.1(0.0)	1.6(0.1)	1.3(0.1)	2.9(0.2)	2.9(0.1)	90.0(7.1)	0.7(0.1)
				Pine forest			
C	4.0(0.0)	2.4(0.3)	3.3(0.5)	5.7(0.3)	2.9(0.3)	165.6(10.3)	1.1(0.2)
N	4.0(0.0)	2.2(0.2)	3.1(0.3)	5.3(0.2)	3.0(0.2)	179.4(13.2)	0.8(0.1)
P	3.9(0.1)	2.1(0.1)	3.0(0.5)	5.1(0.4)	3.3(0.5)	146.3(31.8)	1.0(0.1)
NP	3.9(0.1)	2.1(0.2)	3.0(0.4)	5.2(0.5)	3.4(0.2)	143.3(19.0)	1.3(0.2)

Notes: Soil samples were collected in early February 2007 before the start of fertilization. Values are means with standard error in parentheses (n = 5). There was no statistical difference of soil properties among the treatments in each forest, as determined by one-way ANOVA.

Table S2. Effects of N and P addition on soil properties in different sampling periods in the old-growth forest.

Statistical analyses		One-way ANOVA				Repeated measures ANOVA		
Treatment		C	N	P	NP	N	P	N×P
pH	2007 August	4.0(0.0)b	4.0(0.0)b	4.1(0.0)a	4.1(0.0)a	ns	**	ns
	2008 February	4.0(0.1)ab	3.9(0.0)b	4.0(0.0)a	4.0(0.0)ab			
	2008 August	3.8(0.0)	3.8(0.0)	3.9(0.1)	3.9(0.0)			
	2009 February	3.9(0.0)b	3.9(0.0)b	4.0(0.0)a	3.9(0.0)b			
	2009 August	3.8(0.0)	3.8(0.0)	3.9(0.0)	3.9(0.0)			
NH_4^+ (mg kg^{-1})	2007 August	12.3(1.3)	15.0(1.2)	11.1(1.8)	17.0(3.7)	ns	ns	ns
	2008 February	11.1(1.3)	12.3(1.4)	11.2(1.5)	10.8(2.2)			
	2008 August	4.4(1.1)	4.4(1.2)	5.7(0.9)	4.8(0.7)			
	2009 February	10.1(0.8)	12.4(1.1)	12.5(1.6)	11.5(0.9)			
	2009 August	5.5(0.2)	6.4(0.4)	7.0(0.6)	7.0(0.6)			
NO_3^- (mg kg^{-1})	2007 August	7.0(1.6)	7.0(0.2)	4.8(3.0)	3.6(0.6)	ns	**	ns
	2008 February	8.6(1.3)b	13.4(0.8)a	9.6(1.2)ab	6.6(1.0)b			
	2008 August	3.0(0.3)a	2.2(0.5)a	0.6(0.2)b	0.3(0.1)b			
	2009 February	5.4(0.4)a	5.0(0.3)a	3.9(0.3)b	3.9(0.2)b			
	2009 August	5.5(0.5)a	5.2(0.6)a	3.7(0.7)ab	3.2(0.3)b			
NH_4^+ +NO_3^- (mg kg^{-1})	2007 August	19.3(0.9)	22.0(1.4)	16.9(2.3)	20.6(3.5)	ns	ns	ns
	2008 February	19.7(2.0)ab	25.7(2.1)a	20.8(2.2)ab	17.4(2.8)b			
	2008 August	7.4(1.2)	6.6(0.9)	6.3(1.1)	5.1(0.7)			
	2009 February	15.5(0.9)	17.4(1.1)	16.4(1.3)	15.5(0.9)			
	2009 August	11.0(0.4)	11.7(0.7)	10.8(0.3)	10.2(0.6)			
Available P (mg kg^{-1})	2007 August	2.2(0.5)b	2.3(0.2)b	12.1(2.7)a	10.7(2.8)a	ns	**	*
	2008 February	0.4(0.0)b	0.4(0.0)b	1.7(0.3)a	1.1(0.1)a			
	2008 August	0.5(0.1)c	0.9(0.1)c	2.8(0.4)a	1.8(0.3)b			
	2009 February	2.1(0.4)b	6.5(2.4)ab	12.7(1.1)a	8.2(1.9)ab			
	2009 August	1.8(0.1)b	3.4(0.5)b	14.1(4.0)a	6.9(1.9)ab			
Soil organic C (%)	2007 August	4.2(0.5)	4.2(0.2)	4.9(0.4)	4.0(0.3)	ns	ns	ns
	2008 February	3.6(0.5)b	4.4(0.3)ab	4.2(0.3)ab	4.9(0.3)a			
	2008 August	4.4(0.4)	4.9(0.5)	5.3(0.2)	4.4(0.4)			
	2009 February	4.3(0.5)	4.5(0.4)	4.6(0.3)	4.0(0.2)			
	2009 August	4.0(0.5)	5.1(0.6)	5.3(0.1)	4.7(0.5)			
Microbial biomass C (mg kg^{-1})	2007 August	443.1(20.5)ab	366.0(29.9)b	516.3(50.1)a	504.9(43.0)a	ns	*	*
	2008 February	177.8(5.3)ab	141.4(11.1)b	174.2(24.1)ab	201.1(13.2)a			
	2008 August	522.3(13.5)	396.0(73.1)	389.0(52.3)	479.9(55.0)			
	2009 February	295.3(44.2)	214.1(20.5)	277.2(19.1)	281.8(20.0)			
	2009 August	732.9(80.9)b	682.1(25.5)b	756.3(55.7)ab	975.3(109.5)a			

Notes: Values are means with standard error in parentheses (n = 5). February and August is within the dry and wet season, respectively in the study region. Different lowercase letters represent significant difference among the treatments. '**', '*' and 'ns' represent statistical difference of $P<0.01$, $P<0.05$ and $P>0.05$, respectively.

Table S3. Effects of N and P addition on soil properties in different sampling periods in the mixed forest.

Statistical analyses		One-way ANOVA				Repeated measures ANOVA		
Treatment		C	N	P	NP	N	P	N×P
pH	2007 August	4.2(0.1)	4.2(0.0)	4.2(0.0)	4.1(0.0)	ns	ns	*
	2008 February	4.1(0.0)	4.1(0.0)	4.1(0.0)	4.0(0.0)			
	2008 August	4.0(0.0)	4.0(0.0)	4.0(0.1)	3.9(0.0)			
	2009 February	3.9(0.0)b	4.0(0.0)ab	4.1(0.0)a	4.0(0.0)ab			
	2009 August	4.1(0.0)ab	4.0(0.0)ab	4.1(0.0)a	4.0(0.0)b			
NH_4^+ (mg kg^{-1})	2007 August	12.9(1.4)	14.2(1.6)	14.4(1.1)	13.7(0.6)	ns	ns	ns
	2008 February	9.7(0.8)	10.6(0.7)	11.0(1.3)	12.1(1.1)			
	2008 August	1.5(0.2)	2.1(0.2)	2.5(0.6)	2.4(0.4)			
	2009 February	11.4(1.0)	10.3(0.7)	10.0(0.6)	9.9(0.3)			
	2009 August	6.3(0.4)	7.1(0.7)	6.4(0.4)	7.0(0.6)			
NO_3^- (mg kg^{-1})	2007 August	1.6(0.2)ab	1.6(0.3)ab	0.7(0.2)b	1.8(0.3)a	ns	*	**
	2008 February	1.0(0.2)a	1.0(0.2)a	0.1(0.0)b	0.9(0.2)ab			
	2008 August	0.2(0.1)	0.2(0.0)	0.1(0.0)	0.3(0.1)			
	2009 February	4.2(0.2)a	3.8(0.2)ab	3.3(0.1)c	3.4(0.1)bc			
	2009 August	2.5(0.1)	2.5(0.3)	1.9(0.1)	2.8(0.5)			
NH_4^+ +NO_3^- (mg kg^{-1})	2007 August	14.5(1.4)	15.8(1.4)	15.2(1.2)	15.5(0.7)	ns	ns	ns
	2008 February	10.8(0.9)	11.6(0.6)	11.1(1.3)	13.0(1.4)			
	2008 August	1.7(0.3)	2.3(0.3)	2.7(0.6)	2.7(0.3)			
	2009 February	15.6(0.8)a	14.2(0.6)ab	13.3(0.6)b	13.2(0.3)b			
	2009 August	8.8(0.3)	9.6(1.0)	8.3(0.5)	9.8(0.8)			
Available P (mg kg^{-1})	2007 August	1.5(0.5)b	1.3(0.2)b	12.3(4.7)a	13.5(3.1)a	ns	**	ns
	2008 February	0.4(0.0)b	0.4(0.0)b	1.6(0.5)a	1.6(0.4)a			
	2008 August	1.8(0.5)	2.9(1.0)	6.0(2.6)	3.2(0.7)			
	2009 February	2.2(0.1)b	9.2(2.2)a	10.5(2.3)a	7.7(0.9)a			
	2009 August	1.4(0.1)b	4.8(1.3)a	5.5(1.3)a	2.8(0.5)ab			
Soil organic C (%)	2007 August	2.2(0.1)ab	2.7(0.2)a	1.9(0.3)b	2.5(0.1)ab	*	ns	ns
	2008 February	2.6(0.2)	3.0(0.2)	2.8(0.1)	3.0(0.2)			
	2008 August	2.4(0.1)	2.7(0.2)	3.0(0.3)	2.7(0.3)			
	2009 February	3.1(0.3)	2.9(0.3)	2.9(0.3)	3.3(0.3)			
	2009 August	1.7(0.2)b	2.5(0.3)ab	3.0(0.3)a	3.2(0.4)a			
Microbial biomass C (mg kg^{-1})	2007 August	324.2(12.7)b	314.8(14.9)b	280.0(27.0)b	424.6(25.4)a	*	ns	ns
	2008 February	130.9(24.1)a	142.5(21.4)a	53.1(5.2)b	81.3(10.5)ab			
	2008 August	352.3(8.8)	311.8(14.6)	382.1(33.4)	367.0(33.4)			
	2009 February	86.0(20.1)	97.8(20.3)	82.3(20.4)	152.6(36.0)			
	2009 August	305.0(23.4)b	405.9(41.9)ab	404.7(32.5)ab	432.1(29.2)a			

Notes: Values are means with standard error in parentheses (n = 5). February and August is within the dry and wet season, respectively in the study region. Different lowercase letters represent significant difference among the treatments. '**', '*' and 'ns' represent statistical difference of $P<0.01$, $P<0.05$ and $P>0.05$, respectively.

Table S4. Effects of N and P addition on soil properties in different sampling periods in the pine forest.

Statistical analyses		One-way ANOVA				Repeated measures ANOVA		
Treatment		C	N	P	NP	N	P	N×P
pH	2007 August	4.1(0.0)	4.1(0.0)	4.1(0.1)	4.0(0.0)	ns	ns	ns
	2008 February	4.0(0.0)ab	3.9(0.0)b	4.0(0.0)a	3.9(0.0)ab			
	2008 August	4.0(0.0)	4.0(0.0)	4.0(0.1)	4.0(0.0)			
	2009 February	3.9(0.1)	3.8(0.0)	4.0(0.0)	3.9(0.0)			
	2009 August	4.0(0.0)	4.0(0.0)	3.9(0.0)	3.9(0.0)			
NH_4^+ (mg kg^{-1})	2007 August	10.6(1.4)	9.8(1.5)	12.9(1.1)	10.9(1.6)	ns	ns	ns
	2008 February	10.9(0.3)b	14.8(1.2)ab	12.4(0.8)ab	16.3(1.4)a			
	2008 August	3.2(0.4)a	1.7(0.4)ab	1.5(0.4)b	2.2(0.1)ab			
	2009 February	12.2(0.8)a	10.4(0.6)ab	8.3(0.6)b	9.6(0.6)b			
	2009 August	7.0(0.7)	5.7(0.3)	6.2(0.3)	5.6(0.3)			
NO_3^- (mg kg^{-1})	2007 August	3.9(0.7)	4.7(0.9)	2.9(1.3)	4.8(0.9)	*	ns	ns
	2008 February	1.3(0.2)b	2.7(0.4)ab	1.1(0.1)b	3.3(0.7)a			
	2008 August	0.5(0.1)	0.5(0.0)	0.3(0.1)	0.4(0.1)			
	2009 February	5.3(0.5)a	4.7(0.3)ab	4.0(0.2)b	4.1(0.2)ab			
	2009 August	3.4(0.2)	3.3(0.2)	3.4(0.3)	3.5(0.5)			
NH_4^+ +NO_3^- (mg kg^{-1})	2007 August	14.5(1.9)	14.5(2.2)	15.8(2.3)	15.7(1.5)	ns	ns	ns
	2008 February	12.2(0.5)b	17.5(1.2)a	13.4(0.9)b	19.5(1.1)a			
	2008 August	3.7(0.5)a	2.2(0.4)ab	1.9(0.5)b	2.6(0.1)ab			
	2009 February	17.6(1.2)a	15.1(0.7)ab	12.3(0.6)b	13.7(0.7)b			
	2009 August	10.38(0.7)	9.0(0.3)	9.6(0.4)	9.1(0.3)			
Available P (mg kg^{-1})	2007 August	2.9(0.2)b	2.6(0.5)b	15.9(3.1)a	13.1(3.7)a	ns	**	ns
	2008 February	0.4(0.0)b	0.5(0.0)b	1.7(0.2)a	1.6(0.3)a			
	2008 August	0.7(0.2)b	0.6(0.1)b	5.7(1.7)a	5.2(1.7)a			
	2009 February	4.8(1.4)bc	3.7(1.3)c	12.7(2.4)ab	13.4(2.4)a			
	2009 August	0.5(0.1)	0.3(0.1)	2.6(0.7)	2.7(1.0)			
Soil organic C (%)	2007 August	3.0(0.1)	2.6(0.1)	3.3(0.1)	3.0(0.4)	*	ns	ns
	2008 February	3.5(0.2)ab	4.5(0.3)a	3.3(0.3)b	4.5(0.3)a			
	2008 August	3.3(0.2)c	5.1(0.3)a	3.6(0.3)bc	4.5(0.3)ab			
	2009 February	3.4(0.3)ab	2.9(0.4)b	3.3(0.1)ab	4.2(0.4)a			
	2009 August	3.2(0.4)	3.1(0.2)	3.4(0.3)	3.6(0.4)			
Microbial biomass C (mg kg^{-1})	2007 August	329.4(32.1)	306.5(38.6)	277.0(23.1)	296.9(39.0)	ns	ns	ns
	2008 February	30.6(4.2)b	51.9(4.4)ab	81.7(12.0)ab	94.0(22.1)a			
	2008 August	496.7(22.8)	430.9(60.4)	371.0(41.9)	383.6(35.1)			
	2009 February	151.0(37.0)a	74.7(12.6)b	102.6(18.8)ab	77.4(8.4)b			
	2009 August	523.6(41.8)	507.6(44.1)	468.8(43.1)	488.9(22.6)			

Notes: Values are means with standard error in parentheses (n = 5). February and August is within the dry and wet season, respectively in the study region. Different lowercase letters represent significant difference among the treatments. '**', '*' and 'ns' represent statistical difference of $P<0.01$, $P<0.05$ and $P>0.05$, respectively.