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Supplementary material

Appendix 1

Below we have a brief description of the laboratory techniques used to measure and analyse the different cation concentrations. For complete methodology please see the individual papers.

RAINFOR - Exchangeable Ca, Mg, K, Na and Al concentrations determined by the silver thiourea method (Ag-TU; Pleysier and Juo, 1980). Leaf cation concentrations were determined using concentrations of K, Ca and Mg in the extracts were subsequently determined using an Atomic Absorption Spectrophotometer (Model 1100b, Perkin Elmer, 10 Norwalk, CT, USA) as prescribed by Anderson and Ingram (1993). See Quesada et al. 2010 further details.

Golley et al. - The elements selected for study were calcium, magnesium, sodium, potassium, phosphorus, and were analysed in an Atomic Absorption Spectrophotometer. A mixed-acid extractant (sulfuric-nitric-perchloric) was used for digestion of both vegetation and soil samples. For further details see (Golley et al. 1978).

BRIDGE - A semi-quantitative method was used to determine the amount of soil exchangeable K, Ca, Mg, and Na residing on the soil colloid exchange sites by displacement with ammonium acetate solution buffered to pH 7.0 (Baraloto et al. 2012, Baraloto et al. 2011, Fortunel et al. 2014).

Table A1 – Compiled measurements of leaf and soil sodium concentrations from 54 independent sites, based on the RAINFOR datasets of Patino and Quesada (Patino et al. 2012, Quesada et al. 2010), BRIDGE (Baraloto et al. 2012, Fortunel et al. 2014) and Golley et al. 1978 Colombia datasets including averaged plot soil sodium concentrations converted to (mg g^{-1}) from $cmol_c$ kg^{-1} using eq 4 below, averaged plot leaf sodium, aluminium, and potassium concentrations (mg g^{-1}), leaf K over Na, leaf K/Na over soil K/Na. LMA g m^{-2} , latitude, longitude, LAI m^2 m^{-2}, tree biomass Mg C ha^{-1}, soil depth (cm) and structure (converted to an approximate density g cm^{-3}).

Project	Site	region	soil Na g mg^{-1}	leaf Na g mg^{-1}	leaf Al g mg^{-1}	leaf K g mg^{-1}	leaf K/Na mol mol^{-1}	leaf/soil K/Na	LMA g m^{-2}	**latitude**	**longitude**	LAI m^2 m^{-2}	biomass Mg C ha^{-1}	**Depth ** cm**	**Structure *** g cm^{-3}**
RAINFOR	AGP-01	inland	0.001*	0.18	1.09	8.15	46.09	NaN	100.25	-3.74099	-70.3055	5.69	284.31	75	1.2
RAINFOR	AGP-02	inland	0.0046	0.19	0.27	7.24	39.11	3.75	90.10	-3.74124	-70.3025	6.17	280.62	75	1.2
RAINFOR	ALP-11	inland	0.0023	0.45	0.04	5.56	12.38	0.65	124.14	-3.94943	-73.4341	4.62	290.70	120	1.3
RAINFOR	ALP-12	inland	0.0023	0.30	2.80	4.57	15.42	2.22	121.05	-3.94778	-73.4357	5.37	297.63	35	1.3
RAINFOR	ALP-21	inland	0.001*	0.33	0.04	5.32	15.91	NaN	114.53	-3.95295	-73.4374	4.59	298.43	175	1.1
RAINFOR	ALP-22	inland	0.0023	0.29	0.10	5.87	20.35	0.98	95.68	-3.95126	-73.4389	4.53	261.57	175	1.3
RAINFOR	ALP-30	inland	0.001*	0.21	0.06	3.73	18.12	NaN	120.99	-3.95437	-73.4258	4.35	272.25	175	1.1
RAINFOR	BOG-01	inland	0.0138	0.30	0.05	9.45	31.35	5.15	95.41	-0.69852	-76.4822	NaN	302.96	35	1.2
RAINFOR	BOG-02	inland	0.0069	0.16	0.05	12.08	75.94	9.36	100.45	-0.69792	-76.4738	5.01	230.16	35	1.2
RAINFOR	CHO-01	inland	0.0276	0.20	2.29	10.49	52.66	20.19	99.66	-14.3856	-61.1478	NaN	142.75	175	1.2
RAINFOR	CUZ-03	inland	0.0046	0.38	0.06	11.73	30.68	1.76	91.21	-12.4997	-68.963	4.65	228.73	120	1.4
RAINFOR	HCC-21	inland	0.0023	0.29	0.05	9.80	33.57	0.80	77.09	-14.5608	-60.7486	NaN	256.86	75	1.3
RAINFOR	HCC-22	inland	0.0023	0.31	1.96	14.32	46.19	1.77	83.99	-14.5675	-60.7478	NaN	272.48	120	1.1
RAINFOR	JAS-02	inland	0.0092	0.32	2.18	9.44	29.68	8.53	108.34	-1.06833	-77.6153	4.68	262.35	75	1.2
RAINFOR	JAS-03	inland	0.0161	0.29	1.69	9.92	34.12	17.17	102.12	-1.0775	-77.6095	4.31	251.43	120	1.2
RAINFOR	JAS-04	inland	0.0115	0.17	1.89	8.25	48.72	14.01	113.35	-1.07353	-77.6122	4.43	335.08	75	1.2
RAINFOR	JAS-05	inland	0.0299	0.28	0.08	12.94	46.69	24.93	88.41	-1.06167	-77.6217	4.20	287.23	75	1.2

RAINFOR	LFB-01	inland	0.001*	0.26	5.18	9.75	38.21	NaN	80.91	-14.5567	-60.9279	NaN	250.92	175	1
RAINFOR	LFB-02	inland	0.001*	0.27	6.20	6.91	25.20	NaN	105.26	-14.5772	-60.8318	NaN	296.72	175	1
RAINFOR	LOR-01	inland	0.0046	0.17	0.06	9.82	56.21	6.46	97.03	-3.05624	-69.9907	5.99	260.48	120	1.4
RAINFOR	LOR-02	inland	0.0046	0.21	0.33	9.58	46.31	5.33	91.62	-3.0576	-69.993	6.17	300.37	75	1.4
RAINFOR	LSL-01	inland	0.0069	0.31	1.60	7.94	25.91	2.79	83.21	-14.4081	-61.1403	NaN	185.00	75	1.1
RAINFOR	LSL-02	inland	0.0069	0.25	7.93	9.42	37.78	3.83	72.33	-14.4083	-61.1384	NaN	193.93	120	1.1
RAINFOR	SCR-01	inland	0.0023	0.18	0.34	4.54	24.82	2.38	125.79	1.93284	-67.0217	5.18	273.66	175	1
RAINFOR	SCR-04	inland	0.0046	0.14	0.14	9.66	67.69	5.19	743.46	1.9273	-67.0362	5.32	338.62	175	1
RAINFOR	SCR-05	inland	0.0023	0.22	0.12	4.89	22.42	2.58	140.21	1.93	-67.0383	5.35	345.64	175	1
RAINFOR	SUC-01	inland	0.0046	0.20	0.18	6.18	31.21	3.59	113.97	-3.25211	-72.9074	6.10	287.15	175	1.2
RAINFOR	SUC-02	inland	0.0023	0.23	0.09	6.56	28.95	1.51	117.00	-3.25114	-72.9036	4.92	291.36	175	1.3
RAINFOR	SUC-03	inland	0.0138	0.22	0.06	5.44	24.33	4.42	104.32	-3.24695	-72.9224	NaN	330.61	120	1.3
RAINFOR	TAM-01	inland	0.0023	0.16	0.08	8.14	51.90	3.73	98.71	-12.8441	-69.2884	4.83	228.02	175	1.3
RAINFOR	TAM-02	inland	0.0023	0.15	0.07	9.09	62.53	1.80	101.51	-12.8348	-69.2861	4.67	248.83	75	1.4
RAINFOR	TAM-04	inland	0.0023	0.19	0.53	8.77	46.13	2.21	102.82	-12.8365	-69.2783	NaN	271.08	120	1.3
RAINFOR	TAM-05	inland	0.0023	0.13	0.05	5.85	44.32	2.83	92.11	-12.8303	-69.2705	4.24	246.99	120	1.3
RAINFOR	TAM-06	inland	0.0046	0.22	0.06	9.41	43.00	3.30	95.82	-12.8385	-69.296	5.19	237.04	120	1.4
RAINFOR	TAM-07	inland	0.0069	0.22	0.15	6.53	29.56	6.37	105.92	-12.8257	-69.261	3.97	254.23	175	1.2
RAINFOR	TIP-03	inland	0.0184	0.34	0.10	6.64	19.35	7.42	90.66	-0.63888	-76.1546	4.53	257.83	120	1.4
RAINFOR	TIP-05	inland	0.0050	0.18	0.13	8.44	46.28	5.92	110.13	-0.63778	-76.1436	4.60	NaN	120	1.2
RAINFOR	YAN-01	inland	0.0092	0.23	0.13	8.76	38.53	4.03	91.33	-3.43955	-72.8458	4.78	291.90	175	1.3
RAINFOR	YAN-02	inland	0.0069	0.28	0.31	9.88	35.68	3.62	98.63	-3.43393	-72.8431	5.05	302.66	175	1.1
RAINFOR	ELD-01	coastal	NaN	1.82	NaN	NaN	NaN	NaN	78.17	6.102119	-61.4034	NaN	NaN	NaN	NaN
RAINFOR	ELD-02	coastal	NaN	2.26	NaN	NaN	NaN	NaN	79.42	6.102119	-61.4045	NaN	NaN	NaN	NaN
RAINFOR	ELD-03	coastal	NaN	1.48	NaN	NaN	NaN	NaN	77.37	6.083267	-61.4046	NaN	NaN	NaN	NaN
RAINFOR	ELD-04	coastal	NaN	1.01	NaN	NaN	NaN	NaN	77.39	6.083281	-61.4057	NaN	NaN	NaN	NaN
Golley et al. 1978	Curiche	coastal	0.088	3.17	NaN	NaN	1.78	4.36	NaN	7.6	-75	NaN	NaN	NaN	NaN

Golley et al. 1978	Alto Curiche	coastal	0.072	3.10	NaN	NaN	2.12	3.17	NaN	8.05	-76	NaN	NaN	NaN	NaN
Golley et al. 1978	RioNercua	coastal	0.116	1.42	NaN	NaN	7.67	27.80	NaN	8.2	-75	NaN	NaN	NaN	NaN
Golley et al. 1978	La Teresita	coastal	0.06	1.25	NaN	NaN	9.53	15.89	NaN	8.11	-75	NaN	NaN	NaN	NaN
Golley et al. 1978	La Nueva	coastal	0.224	3.02	NaN	NaN	1.83	4.87	NaN	8	-75	NaN	NaN	NaN	NaN
BRIDGE	G11	coastal	0.16	1.64	NaN	NaN	3.44	3.44	NaN	4.3112	-52.2275	NaN	174.9997	NaN	NaN
BRIDGE	G14	coastal	0.11	1.12	NaN	NaN	5.75	4.52	NaN	4.2924	-52.2358	NaN	495.9804	NaN	NaN
BRIDGE	G17	coastal	0.04	0.98	NaN	NaN	5.53	3.69	NaN	4.3292	-52.2419	NaN	329.8257	NaN	NaN
BRIDGE	G2	coastal	0.01	1.80	NaN	NaN	3.46	3.46	NaN	5.4751	-53.5868	NaN	262.3308	NaN	NaN
BRIDGE	G4	coastal	0.04	1.05	NaN	NaN	7.82	4.47	NaN	5.4817	-53.5759	NaN	351.7571	NaN	NaN
BRIDGE	G8	coastal	0.05	0.63	NaN	NaN	12.59	12.59	NaN	5.4718	-53.5933	NaN	493.287	NaN	NaN

*Listed as 0.00 in Quesada et al. 2010 due to rounding and replaced with 0.001 mg g^{-1} here

**Converted to approximate depth from Quesada et al. 2010

***Converted to approximate soil density from Quesada et al. 2010

$$\frac{cmol_c}{kg} = \frac{1+}{c} * \frac{mol}{100cmol} * \frac{23g}{1\,mol} = \frac{g}{kg} \qquad \text{[Eq 4]}$$

Table A2 – Leaf sodium concentrations (mg g^{-1}), range, species sample size, wood sodium concentrations (mg g^{-1}), range, species sample size and Na/ leaf ratio from Furch and Klinge (1989) from the lower Rio Solimoines for the Varzea sites.

Site	Leaf mg g^{-1}	range	N	wood mg g^{-1}	Range	N	Wood/leaf
Varzea1a	0.201	0.04-1.38	29	0.113	0.01-0.6	29	0.56
Varzea1b	0.05	0.02-1.00	17	0.466	0.16-1.03	18	9.32
Varzea2	0.084	0.020-0.219	13	0.658	0.04-1.51	13	7.83
Igapo	0.236	0.02-1.54	23	0.089	0.01-0.30	22	0.38
terra firme	1.15	0.827	183	0.327	-	224	0.28
Total	0.34		265	0.33		306	3.68*

*spatial mean

Table A3 – Description of the variables modified in the sensitivity analysis and a description of what the uncertainty is.

Variable	Description	Uncertainty	reference
mean wood to leaf sodium ratio	The amount of sodium contained within tropical forest woody biomass compared to the amount in leaves	There are few studies in the tropics where wood sodium is measured. In the one study we found with such measurements, there was a wide ratio of leaf to wood sodium values making prediction difficult.	(Furch and Klinge 1989)
Sea Salt Aerosol input	The total sodium that enters into the ecosystem through sea salt aerosols.	Dry deposition, which is the reference value for the coastal budget sodium yield used in the subject paper, is a small fraction of the atmospheric inputs, and much of this sodium is washed off surfaces by rain and is therefore not easily distinguished from sodium that arrives dissolved in rain water. Stallard (2012b, Table 3) estimates, based on 15 years of measurement on five rivers, that sodium yields from all sources range from 10,000 to 17,000 kg Na km^{-2} yr^{-1} , and that 50% to 80% is atmospheric, depending on the river.	(Stallard, 2012a, Stallard 2012b, Stallard and Edmond 1981)
Loss rate (K)	The mean loss rate of sodium from the system, a function of the total sodium input and the total ecosystem steady state sodium concentration	This is a function of both total ecosystem sodium and total sea salt aerosol input, both of which have large uncertainties associated with them.	Calculated value
Megafauna present in the Amazon basin	Which extinct megafauna existed in the Amazon basin?	Fossils do not preserve well in the humid tropics so it is largely guesswork trying to estimate which such extinct species existed in the Amazon basin. Justification for the species chosen is explained in the supplementary material of (Doughty, C. E. et al. 2013).	(Doughty et al. 2013)
Animal body mass	The estimated mean body mass of a species	The uncertainty of individual species are generally captured with +/-25. However, we use an error of +/- 10% which is for entire communities because as long as the estimates are unbiased the combined error for all co-occurring species will be smaller since some are under and some are over estimated.	(Faurby, S. and Svenning, J. C. 2015a and b, Smith et al. 2003)
Phi coefficient	This is the nutrient diffusion coefficient from equation 1 previously calculated in Doughty et al. and Wolf et al. (2013).	This coefficient is based on 17 species. However, larger datasets with some values missing show similar values. An estimate for just large animals (>44kg) estimated a larger coefficient (1.45).	(Wolf et al. 2013)

Table A4 – Values used in our sensitivity analysis: the estimated range in uncertainty, how this uncertainty was assessed, and a calculation of the Na steady state concentration with megafauna for the coast and inland areas. Expert opinion was estimated by a group of experts (the authors of the paper) of the variable value in which the group was 95% certain the true value would fall within. If the number is calculated as a slope, then the 95% confidence interval (1.96*standard error on the slope) is the potential error.

Variable	Value used	Potential error estimate	How the error was assessed	Past Na steady state concentration	Reference
mean wood to leaf sodium ratio	3.68 wood to leaf sodium ratio	1 – 12 leading to a range in total ecosystem sodium from 50 to 800x10^3 kg km^{-2} along the coast	95% confidence	Coast – 1100-470 Inland – 130 - 10	(Furch and Klinge 1989)
Sea Salt Aerosol input	4000 kg km^{-2} yr^{-1}	1,000 to 10,000 kg Na km^{-2} yr^{-1}	Expert opinion	Coast – 1600-800 Inland – 300 - 50	(Stallard, 2012a, Stallard 2012b, Stallard and Edmond 1981)
Loss rate (K)	0.0130 yr^{-1}	0.007 -0.026	Expert opinion	Coast – 1800-900 Inland – 150 – 10	Calculated value
Megafauna present in Amazon	*Eremotherium, Haplomastodon, Cuvieronius, Toxodon, Neochoerus Tayassuidae*	1-6 megaherbivores (>1000kgs)	Expert opinion	Coast – 600-890 Inland – 170 – 50	(Doughty et al. 2013)
Animal body mass	See (Faurby, S. and Svenning, J. C. 2015a and b, Smith et al. 2003)	±20%	Expert opinion	Coast – 620-580 Inland – 150 – 160	(Faurby, S. and Svenning, J. C. 2015a and b, Smith et al. 2003)
Phi coefficient	1.17	±0.24	Slope error	Coast – 800-500 Inland – 80 – 170	(Wolf et al. 2013)

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