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Supporting Information for

Can leaf spectroscopy predict leaf and forest traits along a Peruvian tropical forest elevation gradient?

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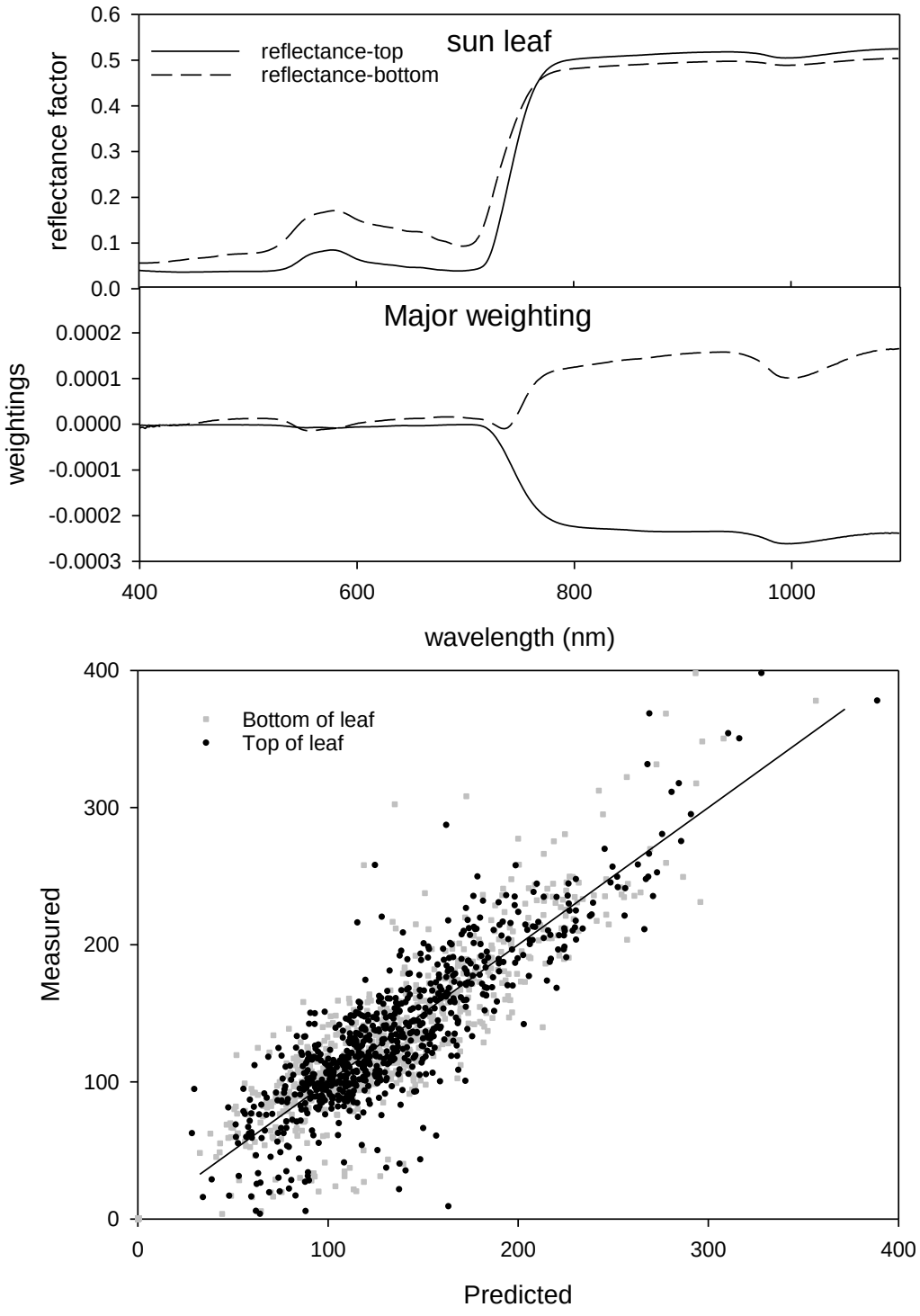
Introduction

This supporting information contains additional text, further plot descriptions in table one, spectral relationships with the bulk chemistry in table two and PLS weightings for LMA based on spectral signatures from mean top and bottom of leaf reflectance.

Supplemental Text

We measured a larger number of chemical components using the Carnegie chemistry measurement protocol on different leaves of the same branches used for leaf spectral signatures (http://spectranomics.ciw.edu). We compared mean chemical values for 589 branches to mean spectral signatures for each branch by averaging the five individual leaves together. The relationships were generally strong (mean for all measured variables r^2=0.32 and %RMSE =40%) (Table S2), but the relationships had lower precision and accuracy than in previous studies (Asner et al 2014c). We explore this further in the discussion, but it is likely due to less available spectral information (400-1075nm versus 400-2500nm), a smaller dataset (589 versus 2567 trees), and sampling on the bulk data rather than the same individual leaves. However, in this study, we were also able to compare the sun and shade leaves. The empirical models based on shade leaves were generally slightly stronger than those based on sun leaves (%RMSE +0.02, r^2-cal +0.01, r^2-test+0.02) (Table S2).



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53 **Figure S1** – Mean top of leaf reflectance (solid line) and bottom of leaf reflectance (dashed line) (top
54 panel). PLS weightings for LMA based on spectral signatures from mean top (black line) and bottom
55 of leaf reflectance (dashed line) (middle panel). Predicted versus measured values of LMA (bottom
56 panel).

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Table S1. Environmental and soil characteristics of 1-ha study plots along a 3300-m tropical montane elevation gradient.

*Derived from high-resolution airborne Light Detection and Ranging (LiDAR) data (see Asner et al. 2013 for methodology)

CHAMBASA plot code	Tambopata 5	Tambopata 6	Pantiacolla 2	Pantiacolla 3	San Pedro 2	San Pedro 1	Trocha Union 4	Esperanza	Wayqecha	Acjanaco 1
RAINFOR site code	TAM-05	TAM-06	PAN-02	PAN-03	SPD-02	SPD-01	TRU-04	ESP-01	WAY-01	ACJ-01
Latitude	-12.8309	-12.8385	-12.6495	-12.6383	-13.0491	-13.0475	-13.1055	-13.1751	-13.1908	-13.14689
Longitude	-69.2705	-69.2960	-71.2626	-71.2744	-71.5365	-71.5423	-71.5893	-71.5948	-71.5874	-71.6323
Elevation* (m)	223	215	595	859	1494	1713	2719	2868	3045	3537
Slope* (deg)	4.5	2.2	11.5	13.7	27.1	30.5	21.2	27.3	30.3	36.3
Aspect* (deg)	186	169	138	160.5	125	117	118	302	112	104
Solar radiation (GJ m^{-2} yr^{-1})	4.8	4.8			4.08	4.36	3.49		3.51	
Mean annual air temperature (°C)**	24.4	24.4	23.5**	21.9**	18.8	17.4	13.5	13.1	11.8	9
Precipitation (mm yr^{-1})	1900	1900	2366**	2835**	5302	5302	2318	1560	1560	3487
Soil moisture (%)	21.8	35.5			37.3	37.6	37.3	24.3	23.1	
Vegetation height*	27.5	28.2	24.4	18.7	22.8	14.0	15.7	16.9	14.3	12.5
Soil type	Cambisol	Alisol	Plintico	Alisol	Cambisol	Cambisol	Umbrisol	Umbrisol	Umbrisol	Cambisol
P_{total} (mg kg^{-1})	256.3	528.8			1630.7	1071.1	746.8	980.8	1413.6	
Soil total N (%)	0.16	0.17			0.9	1.2	1.99	1.48	0.88	
Soil total C (%)	1.51	1.2			13.6	22.7	28.33	28.59	19.33	

**Derived from observations between 6 Feb 2013 and 7 Jan 2014

Table S2 – Spectral relationships with the bulk chemistry based on all leaves not used for photosynthetic measurements on the same branch. R^2-cal is the 70% of the data to calibrate the empirical model and r^2-test is the remaining 30% of the data on which the model was independently tested. Methods for chemical analyses can be found at Carnegie Spectranomics website (http://spectranomics.ciw.edu). The statistics below average five separate PLS regression simulations (each independent run varies because the 70% calibration data is randomly selected).

	Sun leaves				Shade leaves				Difference			
	RMSE	%RMSE	r^2-cal	r^2-test	RMSE	%RMSE	r^2-cal	r^2-test	RMSE	%RMSE	r^2-cal	r^2-test
Chlorophyll A	1.44	0.29	0.33	0.21	1.57	0.31	0.46	0.23	-0.13	-0.03	-0.13	-0.02
Chlorophyll B	0.56	0.30	0.41	0.15	0.58	0.30	0.50	0.18	-0.01	-0.01	-0.10	-0.03
Carotenoids	0.43	0.29	0.25	0.15	0.45	0.31	0.36	0.11	-0.02	-0.01	-0.11	0.04
Soluble carbon	10.71	0.23	0.27	0.02	10.31	0.22	0.37	0.08	0.40	0.01	-0.09	-0.06
Delta 13c	1.39	-0.05	0.54	0.13	1.32	-0.04	0.30	0.05	0.08	0.00	0.24	0.08
Water	6.11	0.11	0.75	0.13	6.67	0.12	0.80	0.12	-0.56	-0.01	-0.05	0.01
Phosphorus (P)	0.04	0.35	0.09	0.02	0.05	0.36	0.18	0.03	0.00	0.00	-0.09	-0.01
Calcium (Ca)	0.42	0.71	0.17	0.02	0.49	0.83	0.11	0.03	-0.07	-0.12	0.06	-0.01
Potassium (K)	0.25	0.39	0.24	0.06	0.28	0.45	0.36	0.11	-0.04	-0.06	-0.12	-0.05
Magnesium (Mg)	0.13	0.45	0.36	0.07	0.14	0.49	0.43	0.09	-0.01	-0.04	-0.07	-0.02
LMA	29.06	0.27	0.72	0.08	20.73	0.19	0.63	0.25	8.32	0.08	0.09	-0.17
Carbon	2.87	0.06	0.15	0.04	2.97	0.06	0.19	0.05	-0.10	0.00	-0.04	-0.01

Lignin	8.99	0.37	0.10	0.01	8.53	0.35	0.16	0.04	0.46	0.02	-0.06	-0.02
Cellulose	5.19	0.31	0.33	0.03	4.63	0.28	0.28	0.02	0.55	0.03	0.05	0.02
Hemi cellulose	3.88	0.34	0.39	0.08	4.05	0.36	0.33	0.05	-0.17	-0.01	0.06	0.03
Phenols	42.44	0.49	0.39	0.09	42.91	0.50	0.32	0.06	-0.47	-0.01	0.07	0.03
Tannins	19.55	0.49	0.42	0.14	21.37	0.53	0.27	0.09	-1.82	-0.05	0.15	0.05
Boron (B)	11.29	0.55	0.09	0.04	12.08	0.59	0.22	0.08	-0.80	-0.04	-0.12	-0.05
Iron (Fe)	30.10	0.46	0.35	0.11	40.09	0.61	0.37	0.15	-9.99	-0.15	-0.01	-0.03
Manganese (Mn)	497.45	1.18	0.37	0.09	449.05	1.06	0.28	0.18	48.40	0.11	0.10	-0.10
Zinc (Zn)	12.00	0.73	0.04	0.02	14.05	0.86	0.05	0.02	-2.05	-0.13	-0.01	0.00