Pantropical modelling of canopy functional traits using Sentinel-2 remote sensing data

Jesús Aguirre-Gutiérrez et al.

Supplementary information
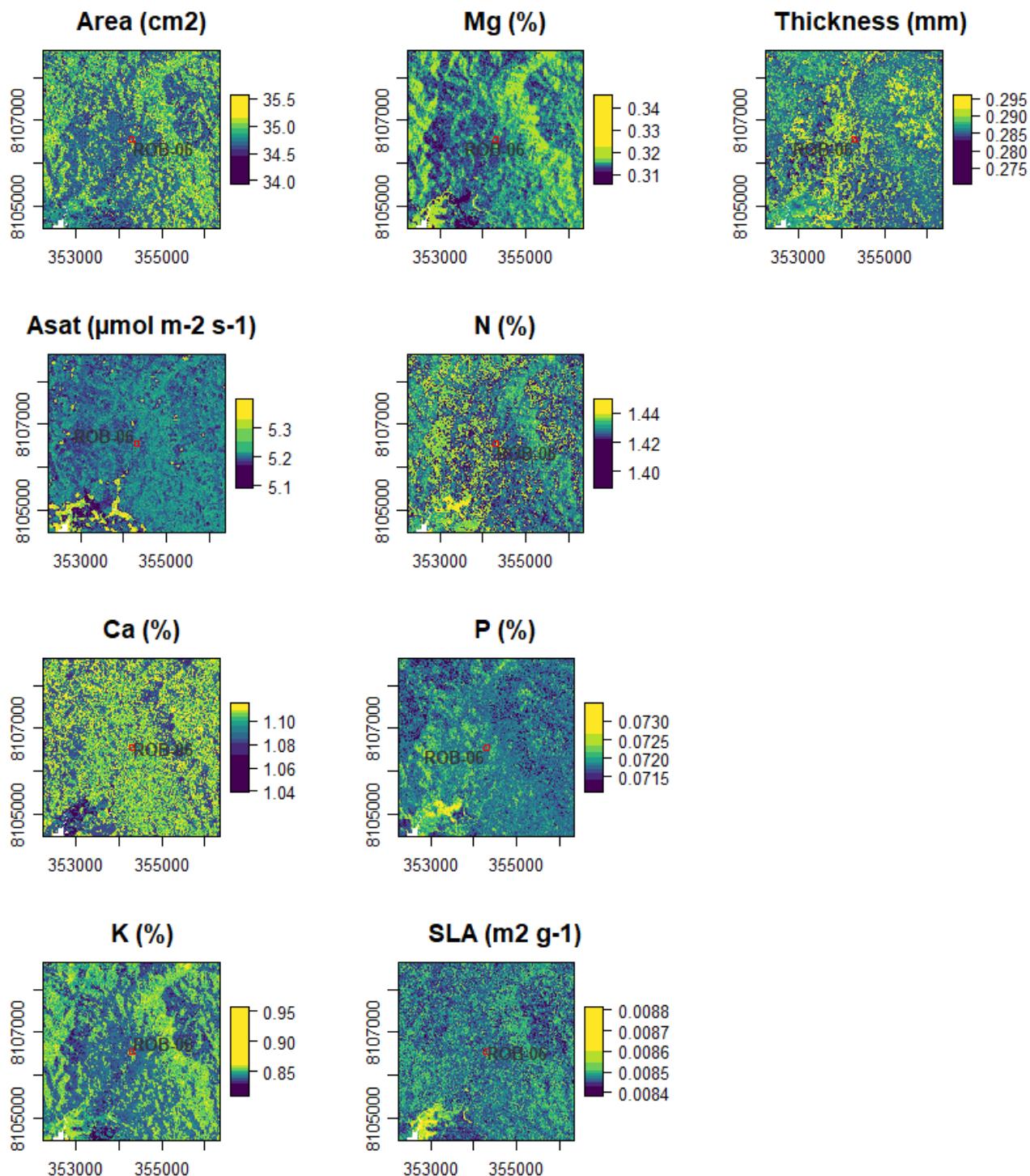
Figure S1. Spatial predictions of trait distributions for plant traits in Australia following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding one of the focus vegetation plots.
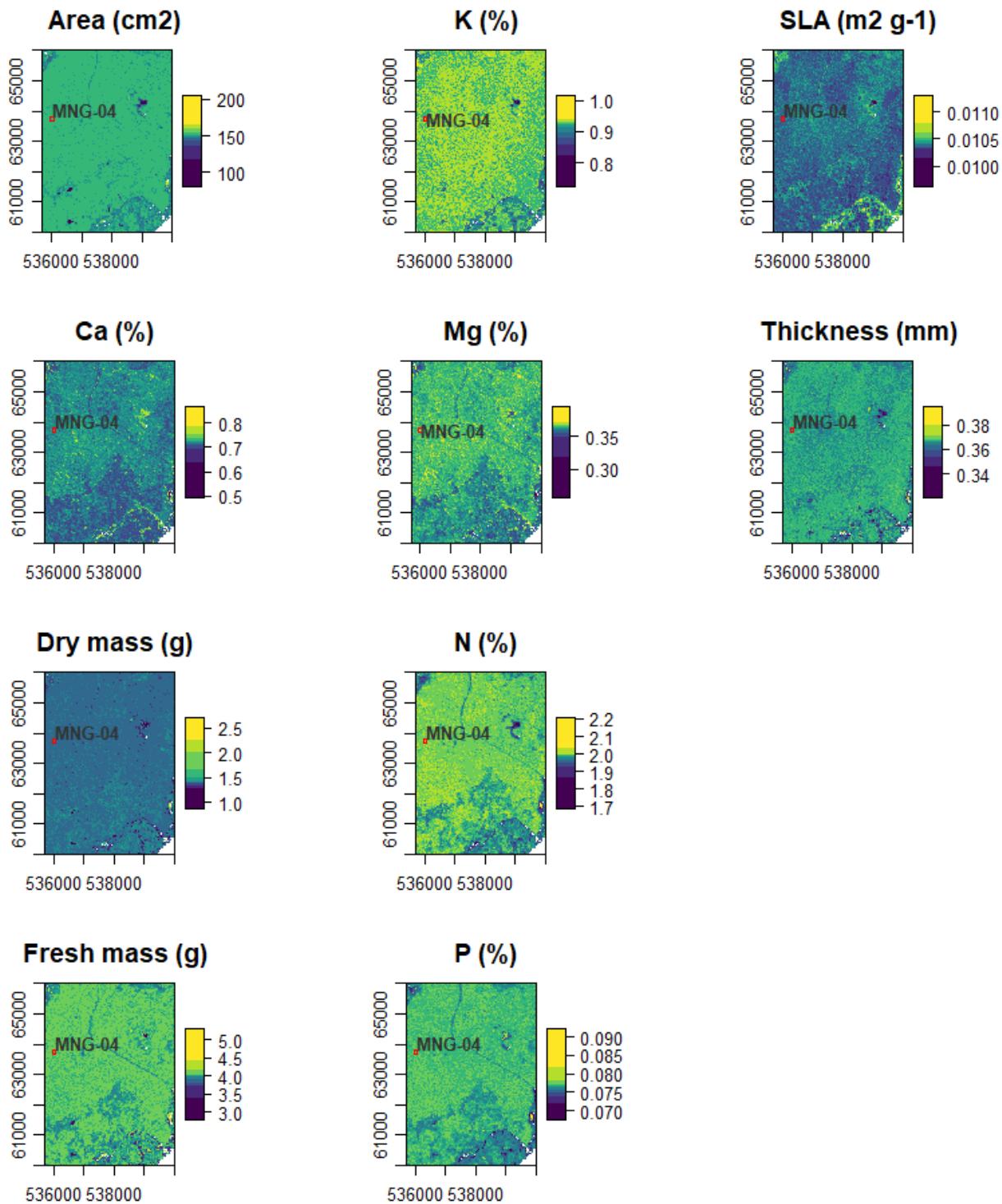
Figure S2. Spatial predictions of trait distributions for plant traits in Gabon following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding one of the focus vegetation plots.
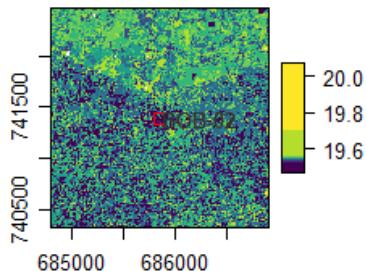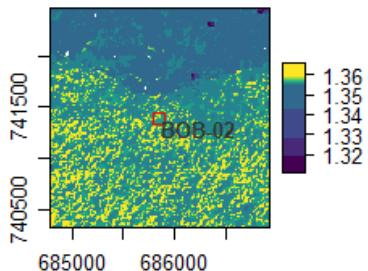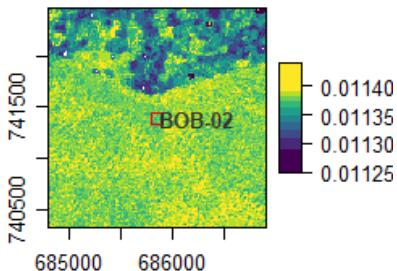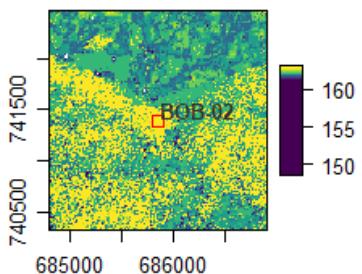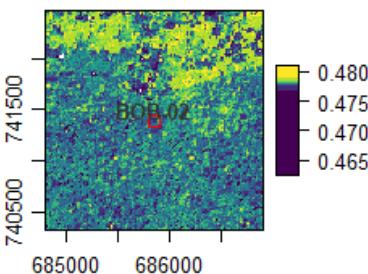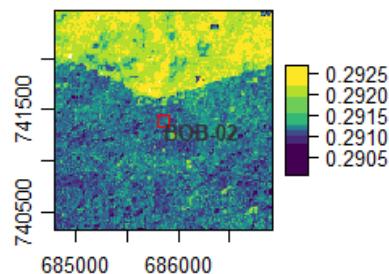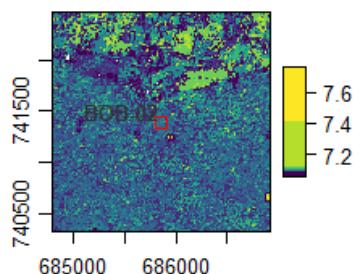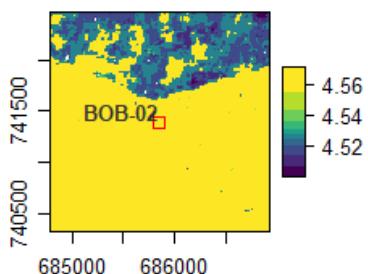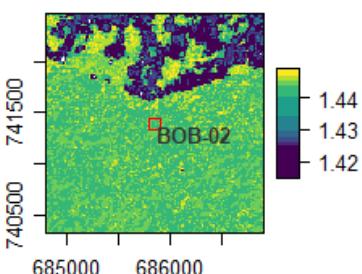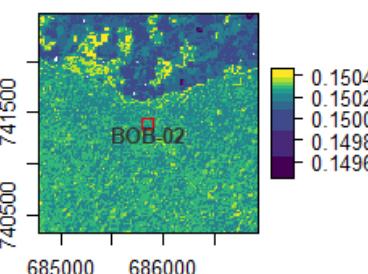
Figure S3. Spatial predictions of trait distributions for plant traits in Ghana following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding one of the focus vegetation plots.
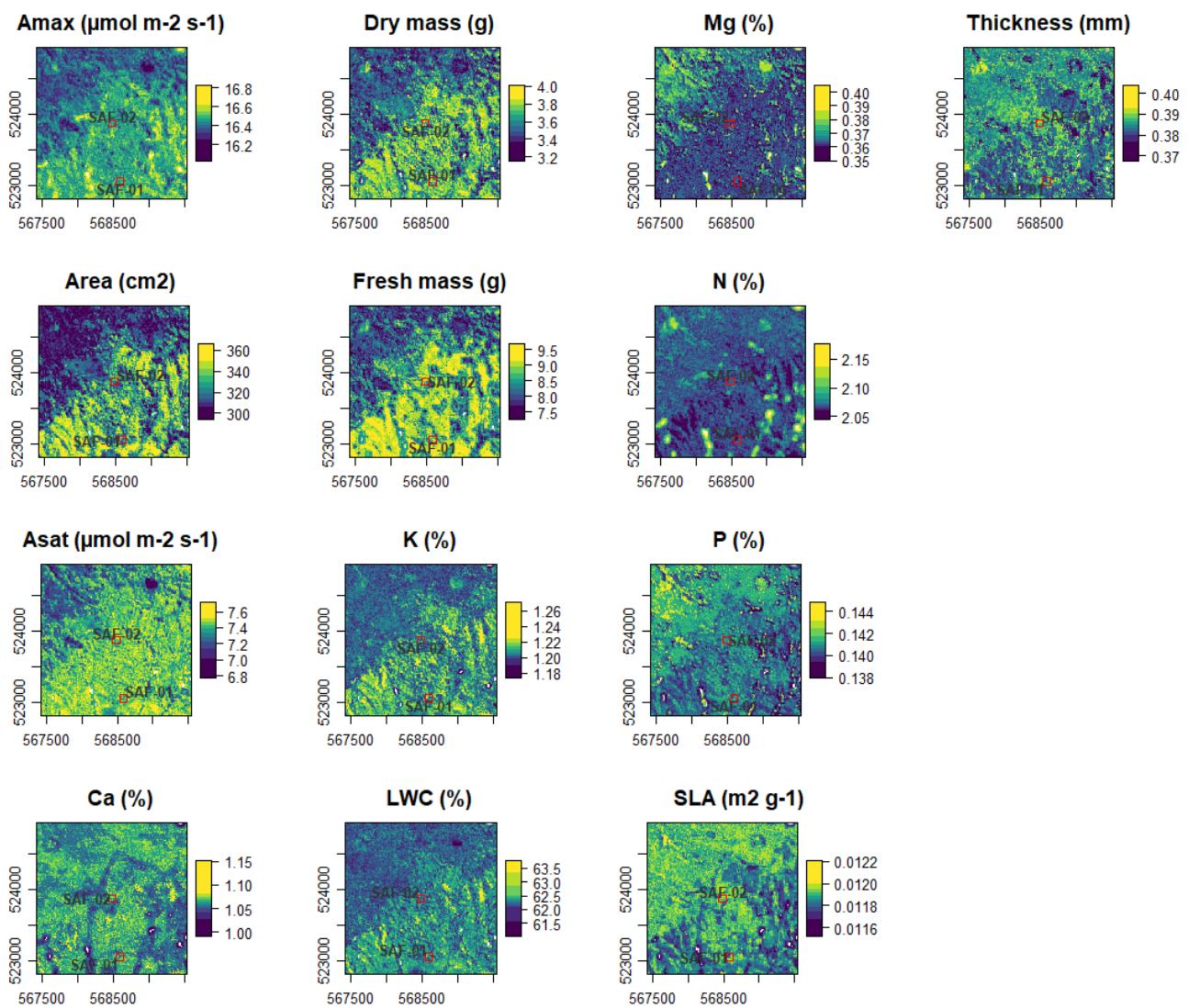
Figure S4. Spatial predictions of trait distributions for plant traits in Malaysia following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding two of the focus vegetation plots.
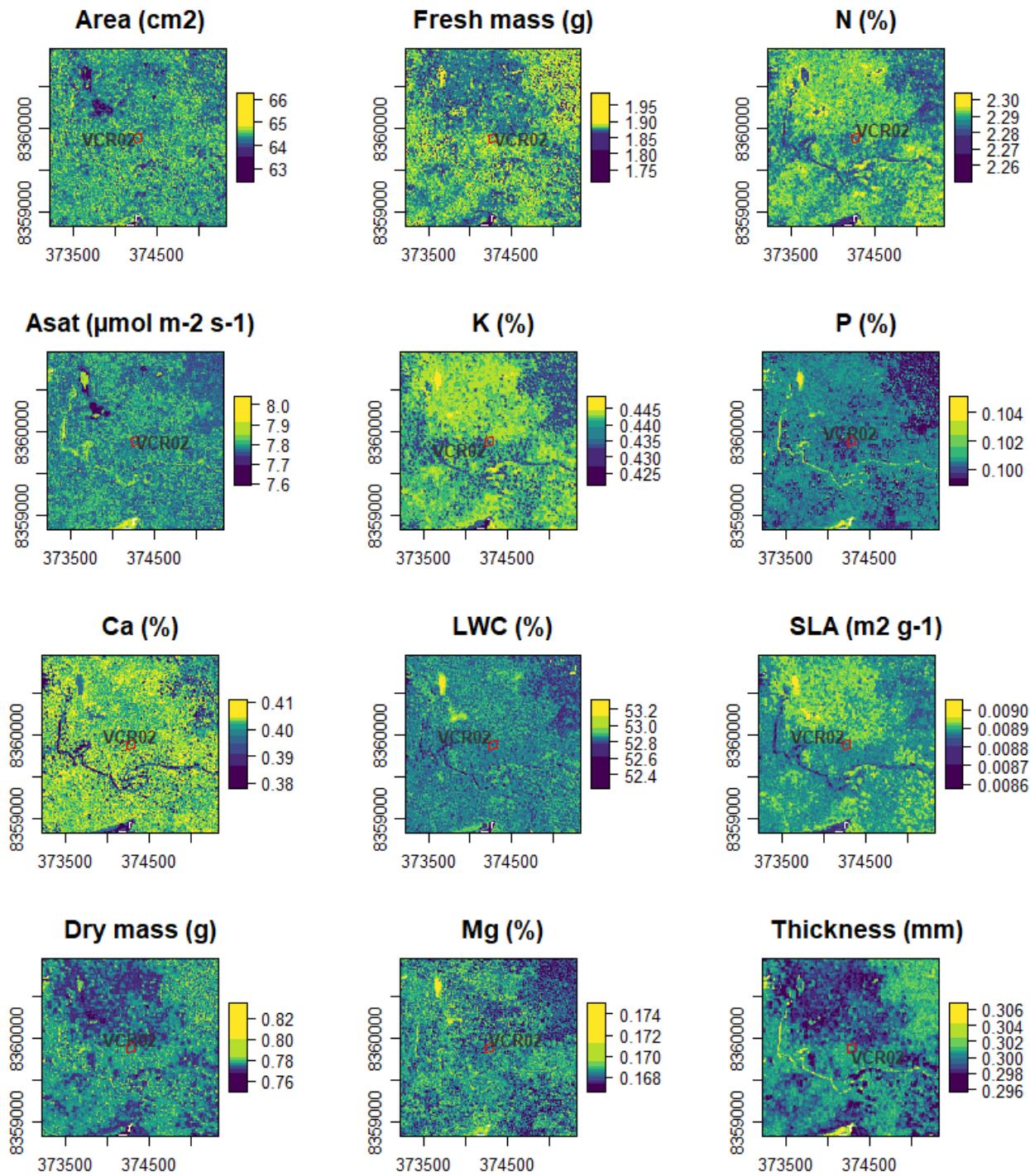
Figure S5. Spatial predictions of trait distributions for plant traits in Brazil -NX (Nova Xavantina) following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding one of the focus vegetation plots.
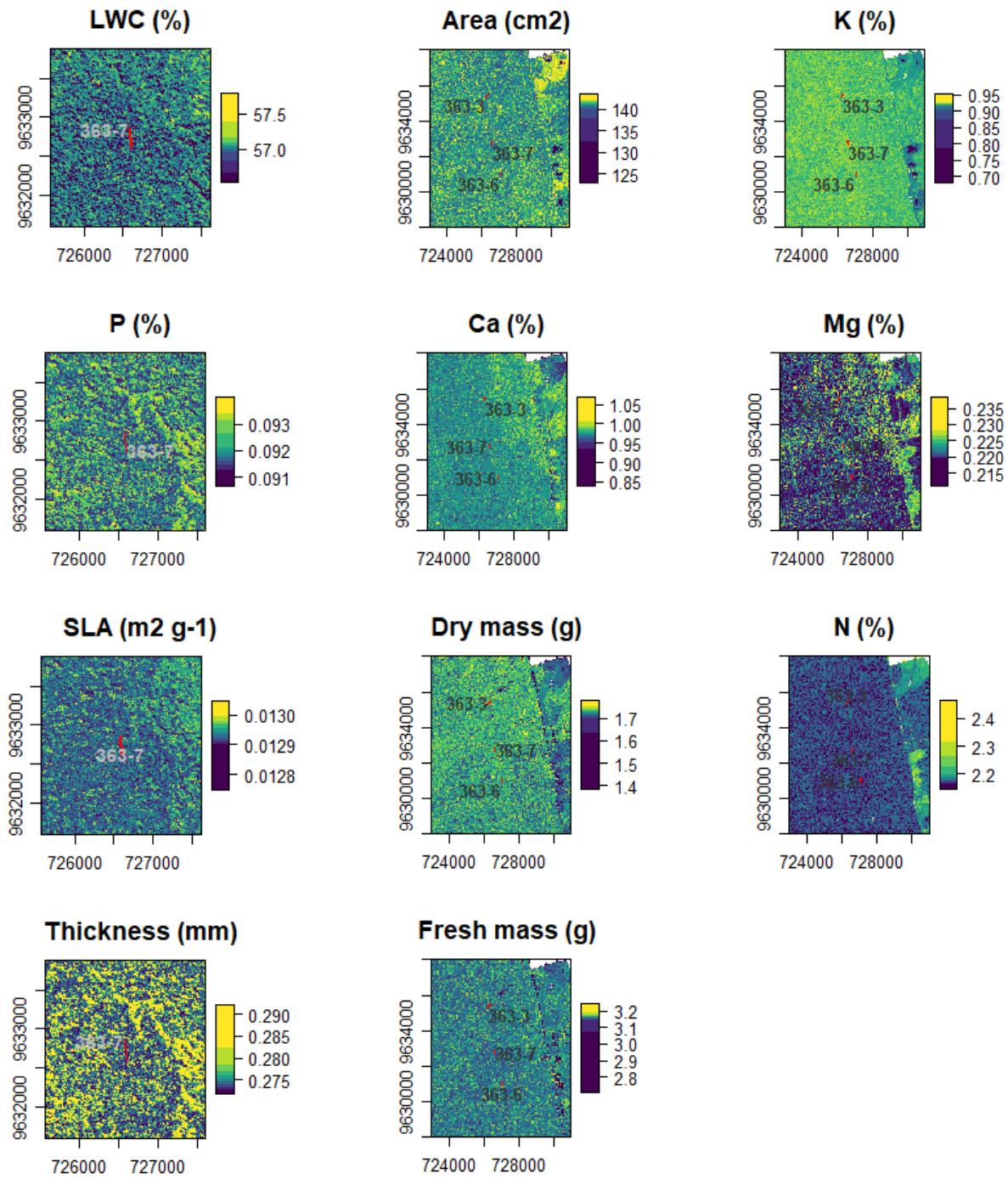
Figure S6. Spatial predictions of trait distributions for plant traits in Brazil -ST (Santarem) following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding three of the focus vegetation plots.
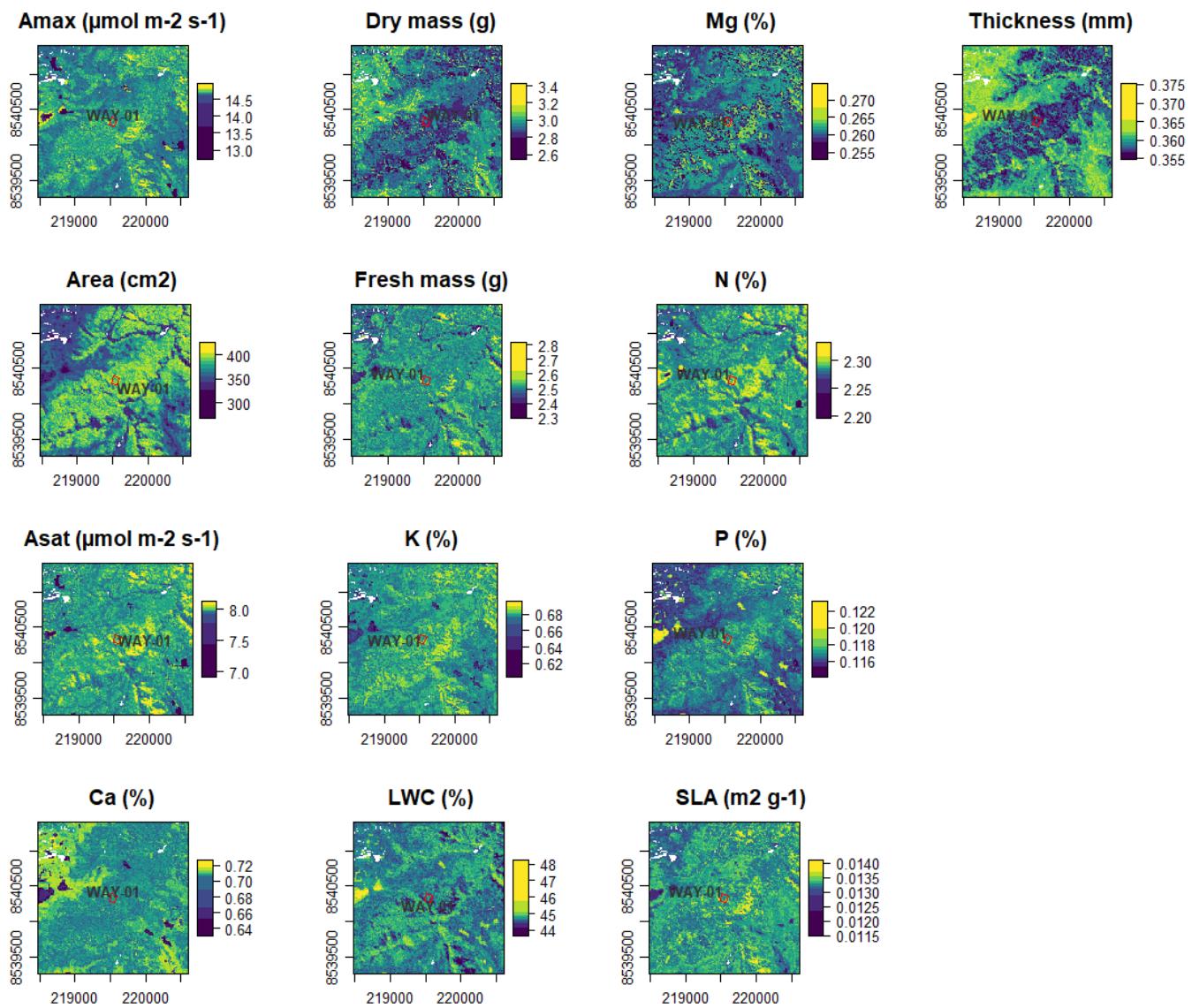
Figure S7. Spatial predictions of trait distributions for plant traits in Peru following the general model and predicting at 10 x 10m pixel resolution. Predictions are only shown for an area surrounding one of the focus vegetation plots.
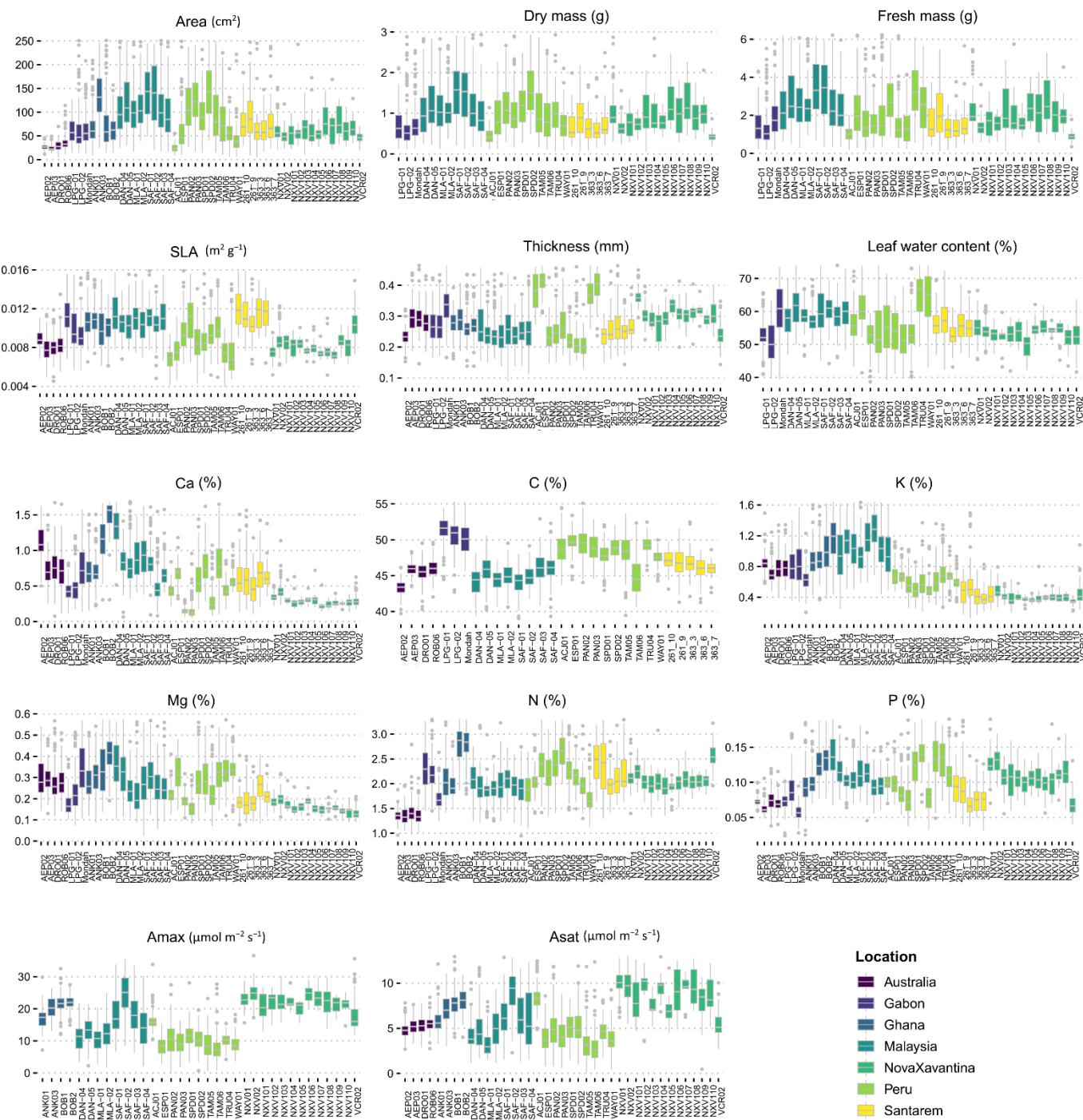
Figure S8. Comparison of trait distributions at the plot level and between tropical regions. For some locations information for all traits was not available. For full details on mean trait value differences among locations see Table S4.
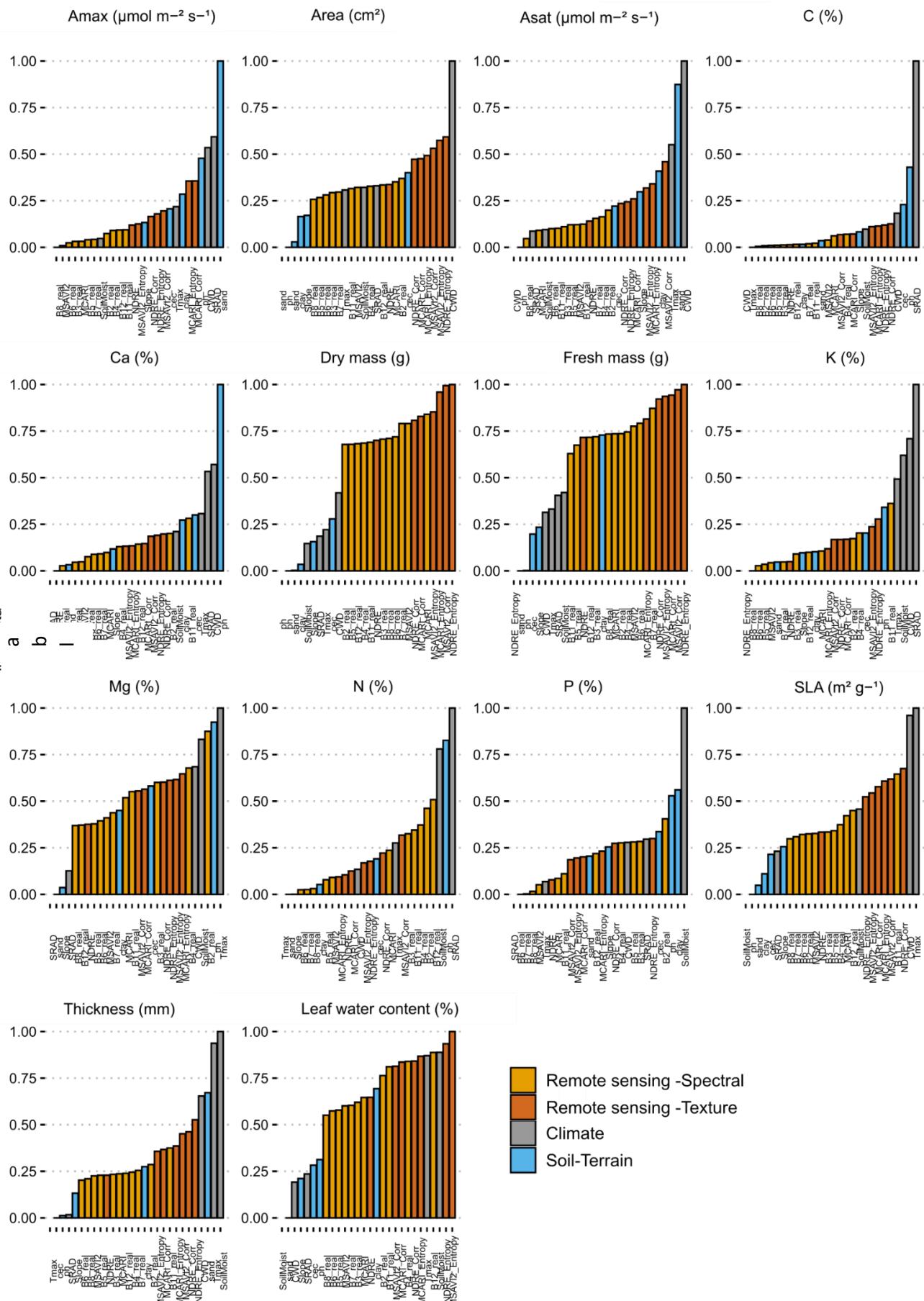
Figure S9. Standardised variable importance of spectral remote sensing, environmental and soil related variables for determining functional trait predictions in the global model. The spectral group contains the select raw bands from the Sentinel-2 and the vegetation indices; Texture contains the Correlation and Entropy metrics from the grey level co-occurrence matrix obtained from the vegetation indices; Climate contains all climatic variables; Soil-Terrain contains all soil characteristics and slope. All variables are described in Table 3.
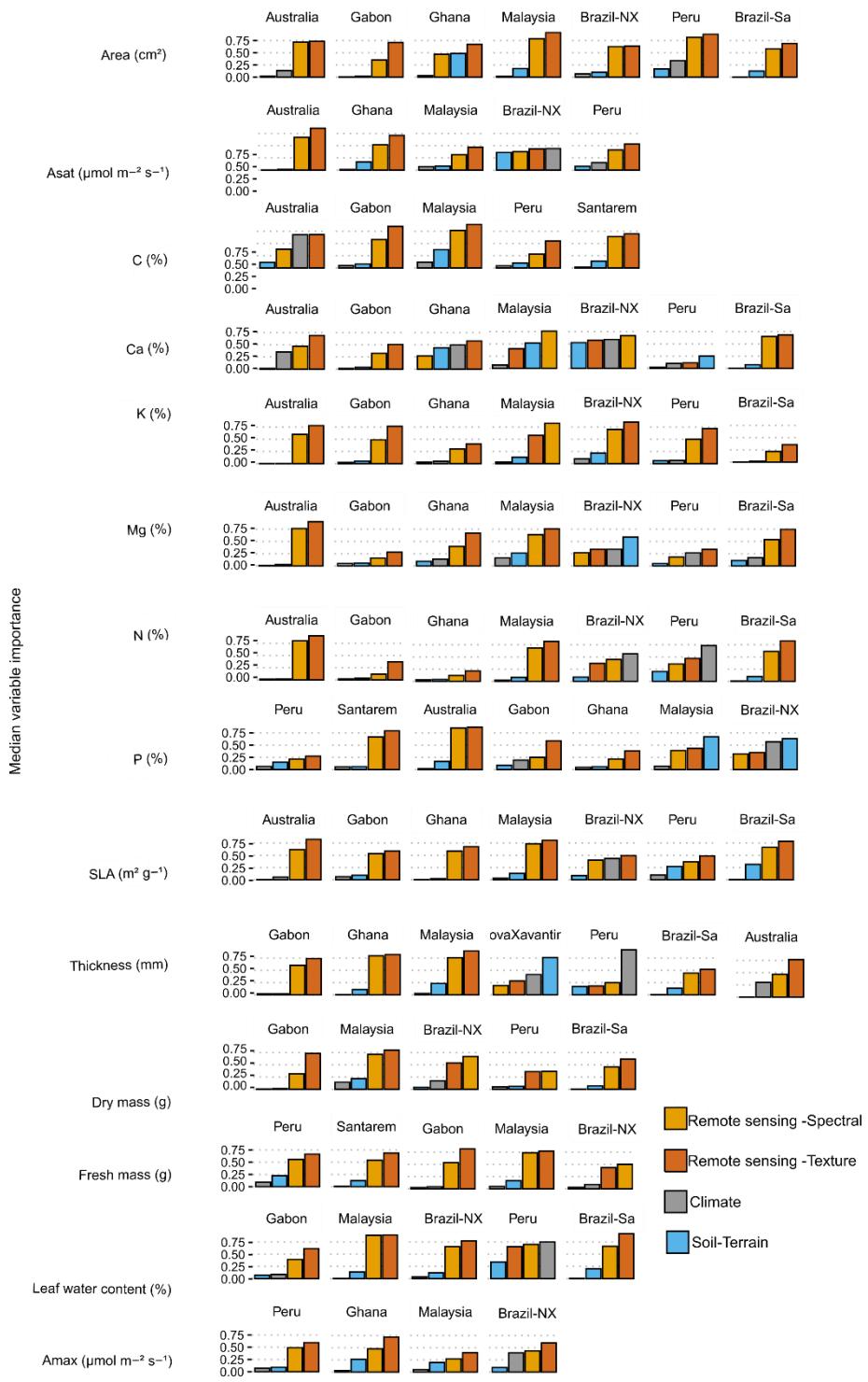
Figure S10. Group averaged variable importance of spectral remote sensing, environmental and soil related variables for determining functional trait predictions in the regional models. The spectral group contains the selected raw bands from the Sentinel-2 and the vegetation indices; Texture contains the Correlation and Entropy metrics from the grey level co-occurrence matrix obtained from the vegetation indices; Climate contains all climatic variables; Soil-Terrain contains all soil characteristics and slope. All variables are described in Table 3.

Full traits collection protocol

<u>Photosynthetic related traits</u>: Selected branches were immediately recut under water and leaf gas exchange measurements undertaken as soon as possible (within 1-2 hours). Photosynthetic capacity (light-saturated net assimilation rate) was measured at both saturating CO_2 concentration (2000 ppm CO_2; A_{max}), and at ambient CO_2 concentration (400 ppm CO_2; A_{sat}) under saturating light conditions and at a temperature of 25 °C using a LICOR 6400-XT.

<u>Leaf chemistry traits</u>: On a different branch, all leaves were removed for bulk chemical analysis at different laboratories depending on the traits campaign.

<u>Morphological and structural traits</u>: Leaf area (hereafter referred to as Area) was determined by scanning the adaxial side of the leaf lamina on a flatbed scanner Canon LiDE220® and analysing images with Matlab code available at https://github.com/bblonder/leafarea (see Neyret et al., 2016 for a full description of methodology). Trait values for compound leaves were analysed at the leaflet level. Specific leaf area (SLA) was determined by dividing leaf area by leaf dry mass. Leaf fresh mass (Fresh mass) was calculated as the fresh weight of the recently obtained leaves. Leaf dry mass (Dry mass) was determined after oven drying at 60 °C leaves for 72 hours or until constant weight. Leaf water content (LWC) was determined by subtracting the dry mass content from the fresh mass, multiplying by 100 and dividing by the fresh mass to obtain percentage water content. The thickness of leaf lamina (Thickness) was measured by taking four micrometre measurements halfway between the mid-vein and the edge of the leaf, avoiding major secondary veins.

Table S1. Description of the European Space Agency Sentinel-2 satellite imagery used.

Country	Sentinel-2 imagery selected
Malaysia	S2A_MSIL1C_20170705T022551_N0205_R046_T50NML_20170705T024459.SAFE
	S2A_MSIL1C_20160610T022552_N0202_R046_T50NNL_20160610T024605.SAFE
	S2A_MSIL1C_20160918T022542_N0204_R046_T50NNL_20160918T024556.SAFE
	S2A_MSIL1C_20180620T022551_N0206_R046_T50NNL_20180620T083834.SAFE
Australia	S2A_MSIL1C_20160708T003032_N0204_R016_T55KCA_20160708T003035.SAFE
	S2A_MSIL1C_20160926T003032_N0204_R016_T55KCA_20160926T003028.SAFE
	S2A_MSIL1C_20160608T002712_N0202_R016_T55KCA_20160608T002733.SAFE
	S2A_MSIL1C_20160502T003732_N0201_R059_T55KCA_20160502T003730.SAFE
	S2A_MSIL1C_20161009T003952_N0204_R059_T55LCC_20161009T003951.SAFE
	S2A_MSIL1C_20161009T003952_N0204_R059_T55KCB_20161009T003951.SAFE
Brazil -ST	S2A_MSIL1C_20160701T140312_N0204_R067_T21MYS_20160701T140309.SAFE
	S2A_MSIL1C_20150819T141046_N0204_R110_T21MYS_20150819T141044.SAFE
Brazil -NX	S2A_MSIL1C_20160317T134032_N0201_R124_T22LCJ_20160317T134035.SAFE
Peru	S2A_MSIL1C_20151020T144932_N0204_R139_T19LDF_20151020T144926.SAFE
	S2A_MSIL1C_20160709T145732_N0204_R039_T19LBF_20160709T145757.SAFE
	S2A_MSIL1C_20160917T150612_N0204_R039_T19LBG_20160917T150614.SAFE
Ghana	S2A_MSIL1C_20151124T102342_N0204_R065_T30NXP_20151124T103016.SAFE
	S2A_MSIL1C_20151224T102432_N0201_R065_T30NWL_20151224T103322.SAFE
	S2A_MSIL1C_20151224T102432_N0201_R065_T30NXN_20151224T103322.SAFE
Gabon	S2A_MSIL1C_20170402T093031_N0204_R136_T32NNF_20170402T093844.SAFE
	S2A_MSIL1C_20170711T093031_N0205_R136_T32NNF_20170711T094456.SAFE
	S2A_MSIL1C_20180124T092251_N0206_R093_T32MQE_20180125T172615.SAFE

All image tiles were downloaded from the European Space Agency (ESA) Sentinel-2 OpenHub
https://scihub.copernicus.eu; Brazil -NX: Nova Xavantina; Brazil -ST: Santarem.

Table S2. Comparison of trait distributions among tropical regions after running an analysis of variance and Tukey's HSD test to compare community weighted mean traits among locations. Non-significant differences are highlighted in grey.

Trait	Locations	Estimate	CI-Low	CI-High	Adj. *P-value*
Amax (μmol m−2 s−1)	Malaysia-Ghana	-0.7165	-0.8100	-0.6229	<0.001
	Brazil NX-Ghana	0.1793	0.0687	0.2899	<0.001
	Brazil NX-Malaysia	0.8957	0.7926	0.9988	<0.001
	Peru-Ghana	-1.3638	-1.4519	-1.2758	<0.001
	Peru-Malaysia	-0.6474	-0.7259	-0.5689	<0.001
	Peru-Brazil NX	-1.5431	-1.6413	-1.4449	<0.001
Area (cm2)	Gabon-Australia	2.5472	1.5720	3.5224	<0.001
	Ghana-Australia	3.7798	2.8664	4.6931	<0.001
	Ghana-Gabon	1.2325	0.3483	2.1168	<0.001
	Malaysia-Australia	7.5715	6.7262	8.4168	<0.001
	Malaysia-Gabon	5.0243	4.2106	5.8380	<0.001
	Malaysia-Ghana	3.7917	3.0533	4.5302	<0.001
	Brazil NX-Australia	2.0138	1.0376	2.9900	<0.001
	Brazil NX-Gabon	-0.5334	-1.4824	0.4156	0.6443
	Brazil NX-Ghana	-1.7660	-2.6513	-0.8806	<0.001
	Brazil NX-Malaysia	-5.5577	-6.3727	-4.7428	<0.001
	Peru-Australia	5.1447	4.3261	5.9633	<0.001
	Peru-Gabon	2.5975	1.8116	3.3834	<0.001
	Peru-Ghana	1.3649	0.6572	2.0727	<0.001
	Peru-Malaysia	-2.4268	-3.0442	-1.8094	<0.001
	Peru-Brazil NX	3.1309	2.3437	3.9181	<0.001
	Brazil ST-Australia	3.4879	2.4057	4.5702	<0.001
	Brazil ST-Gabon	0.9407	-0.1170	1.9984	0.1192
	Brazil ST-Ghana	-0.2918	-1.2929	0.7092	0.9783
	Brazil ST-Malaysia	-4.0836	-5.0229	-3.1443	<0.001
	Brazil ST-Brazil NX	1.4741	0.4154	2.5328	<0.001
	Brazil ST-Peru	-1.6568	-2.5721	-0.7414	<0.001
Asat (μmol m−2 s−1)	Ghana-Australia	0.3792	0.2905	0.4678	<0.001
	Malaysia-Australia	0.0126	-0.0706	0.0957	0.9940
	Malaysia-Ghana	-0.3666	-0.4395	-0.2937	<0.001
	Brazil NX-Australia	0.6046	0.5096	0.6996	<0.001
	Brazil NX-Ghana	0.2255	0.1393	0.3116	<0.001
	Brazil NX-Malaysia	0.5921	0.5115	0.6726	<0.001
	Peru-Australia	-0.1918	-0.2711	-0.1125	<0.001
	Peru-Ghana	-0.5710	-0.6395	-0.5024	<0.001
	Peru-Malaysia	-0.2044	-0.2656	-0.1431	<0.001
	Peru-Brazil NX	-0.7964	-0.8729	-0.7199	<0.001
C (%)	Gabon-Australia	0.3884	0.3566	0.4201	<0.001
	Malaysia-Australia	-0.0400	-0.0675	-0.0124	<0.001
	Malaysia-Gabon	-0.4283	-0.4548	-0.4018	<0.001
	Peru-Australia	0.2163	0.1896	0.2429	<0.001
	Peru-Gabon	-0.1721	-0.1977	-0.1465	<0.001
	Peru-Malaysia	0.2562	0.2361	0.2763	<0.001
	Brazil ST-Australia	0.0765	0.0412	0.1118	<0.001
	Brazil ST-Gabon	-0.3118	-0.3464	-0.2773	<0.001
	Brazil ST-Malaysia	0.1165	0.0858	0.1471	<0.001
	Brazil ST-Peru	-0.1397	-0.1696	-0.1099	<0.001

	Gabon-Australia	-0.1619	-0.2118	-0.1120	<0.001
	Ghana-Australia	0.2615	0.2149	0.3082	<0.001
	Ghana-Gabon	0.4234	0.3782	0.4687	<0.001
	Malaysia-Australia	0.0560	0.0128	0.0992	0.0026
	Malaysia-Gabon	0.2179	0.1763	0.2596	<0.001
	Malaysia-Ghana	-0.2055	-0.2433	-0.1678	<0.001
	Brazil NX-Australia	-0.3203	-0.3702	-0.2704	<0.001
	Brazil NX-Gabon	-0.1584	-0.2069	-0.1098	<0.001
	Brazil NX-Ghana	-0.5818	-0.6270	-0.5366	<0.001
	Brazil NX-Malaysia	-0.3763	-0.4179	-0.3347	<0.001
Ca (%)	Peru-Australia	-0.2092	-0.2509	-0.1674	<0.001
	Peru-Gabon	-0.0473	-0.0874	-0.0071	0.0094
	Peru-Ghana	-0.4707	-0.5068	-0.4347	<0.001
	Peru-Malaysia	-0.2652	-0.2966	-0.2337	<0.001
	Peru-Brazil NX	0.1111	0.0710	0.1512	<0.001
	Brazil ST-Australia	-0.1213	-0.1767	-0.0660	<0.001
	Brazil ST-Gabon	0.0406	-0.0135	0.0947	0.2894
	Brazil ST-Ghana	-0.3829	-0.4340	-0.3317	<0.001
	Brazil ST-Malaysia	-0.1773	-0.2254	-0.1293	<0.001
	Brazil ST-Brazil NX	0.1989	0.1449	0.2530	<0.001
	Brazil ST-Peru	0.0878	0.0411	0.1345	<0.001
	Malaysia-Gabon	0.4365	0.3434	0.5297	<0.001
	Brazil NX-Gabon	-0.0002	-0.1088	0.1084	0.9999
	Brazil NX-Malaysia	-0.4367	-0.5299	-0.3435	<0.001
	Peru-Gabon	0.3140	0.2241	0.4040	<0.001
Dry mass (g)	Peru-Malaysia	-0.1225	-0.1932	-0.0518	<0.001
	Peru-Brazil NX	0.3142	0.2242	0.4042	<0.001
	Brazil ST-Gabon	0.0027	-0.1185	0.1239	0.9999
	Brazil ST-Malaysia	-0.4338	-0.5415	-0.3262	<0.001
	Brazil ST-Brazil NX	0.0029	-0.1184	0.1241	0.9999
	Brazil ST-Peru	-0.3113	-0.4162	-0.2064	<0.001
	Malaysia-Gabon	0.7641	0.6500	0.8782	<0.001
	Brazil NX-Gabon	-0.0187	-0.1517	0.1144	0.9954
	Brazil NX-Malaysia	-0.7828	-0.8970	-0.6686	<0.001
	Peru-Gabon	0.1085	-0.0017	0.2187	0.0559
Fresh mass (g)	Peru-Malaysia	-0.6556	-0.7421	-0.5691	<0.001
	Peru-Brazil NX	0.1272	0.0169	0.2374	0.0143
	Brazil ST-Gabon	0.0085	-0.1400	0.1570	0.9999
	Brazil ST-Malaysia	-0.7556	-0.8875	-0.6237	<0.001
	Brazil ST-Brazil NX	0.0272	-0.1214	0.1758	0.9874
	Brazil ST-Peru	-0.1000	-0.2285	0.0285	0.2101
	Malaysia-Gabon	0.3462	0.2193	0.4730	<0.001
	Brazil NX-Gabon	-0.0373	-0.1851	0.1105	0.9590
	Peru-Gabon	-0.1518	-0.2804	-0.0231	0.0113
	Brazil ST-Gabon	0.0781	-0.0872	0.2434	0.6976
Leaf water content (%)	Brazil NX-Malaysia	-0.3835	-0.5104	-0.2565	<0.001
	Peru-Malaysia	-0.4979	-0.6019	-0.3940	<0.001
	Brazil ST-Malaysia	-0.2681	-0.4150	-0.1211	<0.001
	Peru-Brazil NX	-0.1145	-0.2432	0.0143	0.1083
	Brazil ST-Brazil NX	0.1154	-0.0500	0.2808	0.3151
	Brazil ST-Peru	0.2299	0.0814	0.3784	<0.001
K (%)	Gabon-Australia	-0.0136	-0.0436	0.0164	0.8364
	Ghana-Australia	0.1518	0.1238	0.1799	<0.001

	Ghana-Gabon	0.1654	0.1382	0.1926	<0.001
	Malaysia-Australia	0.1738	0.1478	0.1998	<0.001
	Malaysia-Gabon	0.1874	0.1623	0.2124	<0.001
	Malaysia-Ghana	0.0220	-0.0007	0.0447	0.0649
	Brazil NX-Australia	-0.2413	-0.2713	-0.2114	<0.001
	Brazil NX-Gabon	-0.2278	-0.2570	-0.1986	<0.001
	Brazil NX-Ghana	-0.3932	-0.4203	-0.3660	<0.001
	Brazil NX-Malaysia	-0.4151	-0.4402	-0.3901	<0.001
	Peru-Australia	-0.1111	-0.1362	-0.0860	<0.001
	Peru-Gabon	-0.0976	-0.1217	-0.0734	<0.001
	Peru-Ghana	-0.2629	-0.2846	-0.2413	<0.001
	Peru-Malaysia	-0.2849	-0.3038	-0.2660	<0.001
	Peru-Brazil NX	0.1302	0.1061	0.1543	<0.001
	Brazil ST-Australia	-0.2181	-0.2513	-0.1848	<0.001
	Brazil ST-Gabon	-0.2045	-0.2370	-0.1720	<0.001
	Brazil ST-Ghana	-0.3699	-0.4006	-0.3391	<0.001
	Brazil ST-Malaysia	-0.3918	-0.4207	-0.3630	<0.001
	Brazil ST-Brazil NX	0.0233	-0.0092	0.0558	0.3453
	Brazil ST-Peru	-0.1069	-0.1350	-0.0789	<0.001
	Gabon-Australia	-0.0373	-0.0584	-0.0162	<0.001
	Ghana-Australia	0.0533	0.0335	0.0730	<0.001
	Ghana-Gabon	0.0906	0.0714	0.1097	<0.001
	Malaysia-Australia	0.0030	-0.0153	0.0213	0.9991
	Malaysia-Gabon	0.0403	0.0226	0.0579	<0.001
	Malaysia-Ghana	-0.0503	-0.0663	-0.0343	<0.001
	Brazil NX-Australia	-0.1297	-0.1508	-0.1086	<0.001
	Brazil NX-Gabon	-0.0924	-0.1129	-0.0718	<0.001
	Brazil NX-Ghana	-0.1830	-0.2021	-0.1638	<0.001
	Brazil NX-Malaysia	-0.1327	-0.1503	-0.1150	<0.001
Mg (%)	Peru-Australia	-0.0184	-0.0361	-0.0008	0.0345
	Peru-Gabon	0.0189	0.0019	0.0359	0.0181
	Peru-Ghana	-0.0717	-0.0870	-0.0564	<0.001
	Peru-Malaysia	-0.0214	-0.0347	-0.0081	<0.001
	Peru-Brazil NX	0.1113	0.0943	0.1282	<0.001
	Brazil ST-Australia	-0.0938	-0.1172	-0.0704	<0.001
	Brazil ST-Gabon	-0.0565	-0.0794	-0.0336	<0.001
	Brazil ST-Ghana	-0.1471	-0.1687	-0.1255	<0.001
	Brazil ST-Malaysia	-0.0968	-0.1171	-0.0765	<0.001
	Brazil ST-Brazil NX	0.0359	0.0130	0.0588	<0.001
	Brazil ST-Peru	-0.0754	-0.0952	-0.0556	<0.001
	Gabon-Australia	0.2718	0.2422	0.3015	<0.001
	Ghana-Australia	0.3936	0.3658	0.4214	<0.001
	Ghana-Gabon	0.1218	0.0949	0.1487	<0.001
	Malaysia-Australia	0.2296	0.2039	0.2553	<0.001
	Malaysia-Gabon	-0.0422	-0.0670	-0.0174	<0.001
	Malaysia-Ghana	-0.1640	-0.1864	-0.1415	<0.001
N (%)	Brazil NX-Australia	0.3179	0.2882	0.3476	<0.001
	Brazil NX-Gabon	0.0461	0.0172	0.0749	<0.001
	Brazil NX-Ghana	-0.0757	-0.1026	-0.0488	<0.001
	Brazil NX-Malaysia	0.0883	0.0635	0.1131	<0.001
	Peru-Australia	0.2982	0.2733	0.3231	<0.001
	Peru-Gabon	0.0264	0.0024	0.0503	0.0199
	Peru-Ghana	-0.0954	-0.1169	-0.0739	<0.001

	Peru-Malaysia	0.0686	0.0498	0.0874	<0.001
	Peru-Brazil NX	-0.0197	-0.0436	0.0042	0.1861
	Brazil ST-Australia	0.3348	0.3018	0.3677	<0.001
	Brazil ST-Gabon	0.0629	0.0307	0.0952	<0.001
	Brazil ST-Ghana	-0.0588	-0.0893	-0.0283	<0.001
	Brazil ST-Malaysia	0.1052	0.0765	0.1338	<0.001
	Brazil ST-Brazil NX	0.0169	-0.0154	0.0491	0.7184
	Brazil ST-Peru	0.0366	0.0087	0.0645	0.0022
	Gabon-Australia	0.0026	-0.0070	0.0123	0.9846
	Ghana-Australia	0.0707	0.0617	0.0797	<0.001
	Ghana-Gabon	0.0681	0.0593	0.0768	<0.001
	Malaysia-Australia	0.0692	0.0609	0.0776	<0.001
	Malaysia-Gabon	0.0666	0.0586	0.0747	<0.001
	Malaysia-Ghana	-0.0015	-0.0087	0.0058	0.9972
	Brazil NX-Australia	0.0597	0.0501	0.0694	<0.001
	Brazil NX-Gabon	0.0571	0.0477	0.0665	<0.001
	Brazil NX-Ghana	-0.0110	-0.0197	-0.0022	0.0041
	Brazil NX-Malaysia	-0.0095	-0.0176	-0.0015	0.0090
P (%)	Peru-Australia	0.0647	0.0567	0.0728	<0.001
	Peru-Gabon	0.0621	0.0543	0.0699	<0.001
	Peru-Ghana	-0.0060	-0.0129	0.0010	0.1537
	Peru-Malaysia	-0.0045	-0.0106	0.0016	0.3062
	Peru-Brazil NX	0.0050	-0.0028	0.0128	0.4789
	Brazil ST-Australia	0.0219	0.0112	0.0326	<0.001
	Brazil ST-Gabon	0.0193	0.0088	0.0298	<0.001
	Brazil ST-Ghana	-0.0488	-0.0586	-0.0389	<0.001
	Brazil ST-Malaysia	-0.0473	-0.0566	-0.0380	<0.001
	Brazil ST-Brazil NX	-0.0378	-0.0483	-0.0273	<0.001
	Brazil ST-Peru	-0.0428	-0.0518	-0.0338	<0.001
	Gabon-Australia	0.0118	0.0086	0.0150	<0.001
	Ghana-Australia	0.0114	0.0084	0.0144	<0.001
	Ghana-Gabon	-0.0004	-0.0033	0.0025	0.9997
	Malaysia-Australia	0.0142	0.0114	0.0170	<0.001
	Malaysia-Gabon	0.0023	-0.0003	0.0050	0.1295
	Malaysia-Ghana	0.0027	0.0003	0.0052	0.0150
	Brazil NX-Australia	0.0021	-0.0011	0.0053	0.4573
	Brazil NX-Gabon	-0.0097	-0.0128	-0.0066	<0.001
	Brazil NX-Ghana	-0.0093	-0.0122	-0.0064	<0.001
	Brazil NX-Malaysia	-0.0121	-0.0148	-0.0094	<0.001
SLA (m2 g–1)	Peru-Australia	0.0071	0.0044	0.0098	<0.001
	Peru-Gabon	-0.0047	-0.0073	-0.0022	<0.001
	Peru-Ghana	-0.0043	-0.0067	-0.0020	<0.001
	Peru-Malaysia	-0.0071	-0.0091	-0.0051	<0.001
	Peru-Brazil NX	0.0050	0.0024	0.0076	<0.001
	Brazil ST-Australia	0.0175	0.0139	0.0210	<0.001
	Brazil ST-Gabon	0.0057	0.0022	0.0091	<0.001
	Brazil ST-Ghana	0.0061	0.0028	0.0093	<0.001
	Brazil ST-Malaysia	0.0033	0.0002	0.0064	0.0262
	Brazil ST-Brazil NX	0.0154	0.0119	0.0189	<0.001
	Brazil ST-Peru	0.0104	0.0074	0.0134	<0.001
	Gabon-Australia	0.0151	-0.0018	0.0321	0.1165
Thickness (mm)	Ghana-Australia	-0.0037	-0.0196	0.0122	0.9932
	Ghana-Gabon	-0.0188	-0.0342	-0.0035	0.0056

Malaysia-Australia	-0.0208	-0.0355	-0.0061	<0.001
Malaysia-Gabon	-0.0360	-0.0501	-0.0218	<0.001
Malaysia-Ghana	-0.0171	-0.0299	-0.0043	0.0016
Brazil NX-Australia	0.0191	0.0022	0.0361	0.0155
Brazil NX-Gabon	0.0040	-0.0125	0.0205	0.9918
Brazil NX-Ghana	0.0228	0.0075	0.0382	<0.001
Brazil NX-Malaysia	0.0400	0.0258	0.0541	<0.001
Peru-Australia	0.0385	0.0243	0.0528	<0.001
Peru-Gabon	0.0234	0.0098	0.0371	<0.001
Peru-Ghana	0.0423	0.0300	0.0545	<0.001
Peru-Malaysia	0.0594	0.0486	0.0701	<0.001
Peru-Brazil NX	0.0194	0.0058	0.0331	<0.001
Brazil ST-Australia	-0.0166	-0.0355	0.0022	0.1232
Brazil ST-Gabon	-0.0318	-0.0502	-0.0134	<0.001
Brazil ST-Ghana	-0.0129	-0.0303	0.0045	0.2996
Brazil ST-Malaysia	0.0042	-0.0121	0.0205	0.9888
Brazil ST-Brazil NX	-0.0358	-0.0542	-0.0174	<0.001
Brazil ST-Peru	-0.0552	-0.0711	-0.0393	<0.001

Brazil -NX: Nova Xavantina; Brazil -ST: Santarem.

Table S3. Statistical results for the global trait distribution models constructed with the smaller dataset where the 25th and 50th percentile of smallest trees were removed. The correlation to the results obtained with the full dataset (without removing the smallest trees) is shown.

Type	Dataset	Trait	MAE	MSE	RMSE	R^2	Correlation to full dataset (R2)
Morphological and water content	25% smallest trees out	Area (cm2)	26.71	1360.311063	36.882	0.45	0.95
		Dry mass (g)	0.377	0.256267	0.506	0.27	
		Fresh mass (g)	0.857	1.34205	1.158	0.28	
		SLA (m2 g−1)	0.001	3.00E-06	0.002	0.39	
		Thickness (mm)	0.036	0.002358	0.049	0.51	
		Leaf water content (%)	4.146	30.686676	5.54	0.32	
Chemical		C (%)	1.364	3.358402	1.833	0.61	
		Ca (%)	0.153	0.045916	0.214	0.59	
		K (%)	0.13	0.030804	0.176	0.64	
		Mg (%)	0.056	0.005731	0.076	0.48	
		N (%)	0.238	0.09876	0.314	0.56	
		P (%)	0.016	4.49E-04	0.021	0.56	
Photosynthetic		Amax (μmol m−2 s−1)	3.11	17.122803	4.138	0.64	
		Asat (μmol m−2 s−1)	1.379	3.293167	1.815	0.58	
Morphological and water content	50% smallest trees out	Area (cm2)	29.093	1601.004798	40.013	0.37	0.97
		Dry mass (g)	0.387	0.263549	0.513	0.27	
		Fresh mass (g)	0.838	1.204538	1.098	0.27	
		SLA (m2 g−1)	0.001	3.00E-06	0.002	0.4	
		Thickness (mm)	0.038	0.00252	0.05	0.52	
		Leaf water content (%)	4.144	30.736321	5.544	0.32	
Chemical		C (%)	1.374	3.559623	1.887	0.58	
		Ca (%)	0.162	0.051693	0.227	0.59	
		K (%)	0.145	0.038401	0.196	0.57	
		Mg (%)	0.06	0.00633	0.08	0.42	
		N (%)	0.255	0.110082	0.332	0.52	
		P (%)	0.016	4.53E-04	0.021	0.55	
Photosynthetic		Amax (μmol m−2 s−1)	3.437	20.261913	4.501	0.6	

Asat (μmol m−2 s−1)	1.452	3.734509	1.932	0.54

MAE: Mean Absolute Error; MSE: Mean Square Error; RMSE: Root mean square error.

Table S4. Statistical results for the models fitted per region for each functional trait constructed with the smaller dataset where the 25th and 50th percentile of smallest trees was removed. The correlation to the results obtained with the full dataset (without removing the smallest trees) per trait and the overall correlation over all traits across regions is shown.

Locations	Dataset	Trait	MAE	MSE	RMSE	R²	Correlation to full dataset	Overall correlation to full dataset
	25% smallest trees out	Amax (µmol m−2 s−1)	4.4075	30.8047	5.5502	0.42		
		Area (cm2)	149.4096	71974.0935	268.2799	0.07		
		Asat (µmol m−2 s−1)	1.86	5.6441	2.3757	0.44		
		C (%)	1.5683	4.8068	2.1924	0.27		
		Ca (%)	0.2704	0.3459	0.5881	0.31		
		Dry mass (g)	1.7823	11.9282	3.4537	0.04		
Malaysia		Fresh mass (g)	4.3969	72.2848	8.502	0.04	0.86	
		Leaf water content (%)	3.8173	26.2822	5.1266	0.19		
		K (%)	0.2888	0.1736	0.4166	0.27		
		Mg (%)	0.0968	0.0176	0.1326	0.22		
		N (%)	0.2589	0.1483	0.3851	0.19		
		P (%)	0.0255	0.0024	0.0487	0.16		0.81
		SLA (m2 g−1)	0.0016	0	0.0024	0.11		
		Thickness (mm)	0.0543	0.0094	0.097	0.26		
		Amax (µmol m−2 s−1)	2.7177	11.8535	3.4429	0.42		
		Area (cm2)	16.4847	642.7476	25.3525	0.09		
		Asat (µmol m−2 s−1)	1.5203	3.5129	1.8743	0.59		
		Ca (%)	0.0701	0.0092	0.0961	0.43		
		Dry mass (g)	0.2416	0.1682	0.4101	0.29		
Brazil -NX		Fresh mass (g)	0.6086	1.2114	1.1006	0.24	0.95	
		Leaf water content (%)	3.0527	18.5636	4.3085	0.06		
		K (%)	0.0743	0.0112	0.1058	0.14		
		Mg (%)	0.0207	7.00E-04	0.0267	0.61		
		N (%)	0.1737	0.0506	0.2249	0.51		
		P (%)	0.0146	3.00E-04	0.0183	0.64		

	SLA (m2 g−1)	8.00E-04	0	0.0011	0.55	
	Thickness (mm)	0.0242	0.0011	0.0329	0.65	
Peru	Amax (µmol m−2 s−1)	2.698	13.1243	3.6228	0.38	
	Area (cm2)	93.2267	30998.2922	176.0633	0.26	
	Asat (µmol m−2 s−1)	1.483	3.855	1.9634	0.39	
	C (%)	1.4817	4.104	2.0258	0.29	
	Ca (%)	0.1357	0.0365	0.191	0.68	
	Dry mass (g)	1.2982	5.8398	2.4166	0.14	
	Fresh mass (g)	1.068	2.3976	1.5484	0.22	0.92
	Leaf water content (%)	10.1376	219.9969	14.8323	0.33	
	K (%)	0.1059	0.0197	0.1403	0.26	
	Mg (%)	0.0595	0.0075	0.0865	0.48	
	N (%)	0.2524	0.1082	0.3289	0.47	
	P (%)	0.0216	9.00E-04	0.0303	0.45	
	SLA (m2 g−1)	0.0031	0	0.0059	0.38	
	Thickness (mm)	0.0559	0.0065	0.0805	0.73	
Brazil -ST	Area (cm2)	47.4017	5042.7689	71.0125	0.01	
	C (%)	1.3916	3.1239	1.7675	0.11	
	Ca (%)	0.2632	0.1094	0.3308	0.03	
	Dry mass (g)	0.4504	0.4184	0.6468	0.01	
	Fresh mass (g)	1.0677	2.6544	1.6292	0.31	
	Leaf water content (%)	4.0807	32.3078	5.684	0.09	
	K (%)	0.1252	0.0288	0.1697	0.33	0.72
	Mg (%)	0.057	0.0053	0.0728	0.25	
	N (%)	0.382	0.2621	0.512	0.25	
	P (%)	0.0245	0.0011	0.0338	0.34	
	SLA (m2 g−1)	0.0019	0	0.0025	0.21	
	Thickness (mm)	0.0503	0.0053	0.0727	0.29	
	Amax (µmol m−2 s−1)	2.2485	9.538	3.0884	0.29	
	Area (cm2)	36.2236	2725.1935	52.2034	0.37	
Ghana	Asat (µmol m−2 s−1)	1.3194	3.6126	1.9007	0.11	0.42
	Ca (%)	0.3773	0.3294	0.574	0.57	
	K (%)	0.2965	0.1509	0.3884	0.3	

		Mg (%)	0.0947	0.0137	0.1172	0.29	
		N (%)	0.3622	0.6545	0.809	0.22	
		P (%)	0.0182	7.00E-04	0.0255	0.42	
		SLA (m2 g−1)	0.0014	0	0.0018	0.24	
		Thickness (mm)	0.0308	0.0017	0.0406	0.09	
Australia		Area (cm2)	8.4681	202.7337	14.2385	0.29	
		Asat (µmol m−2 s−1)	0.7602	1.026	1.0129	0.08	
		C (%)	1.0098	1.8311	1.3532	0.38	
		Ca (%)	0.2379	0.1211	0.348	0.16	
		K (%)	0.1366	0.0318	0.1783	0.13	0.68
		Mg (%)	0.0703	0.0098	0.0991	0.06	
		N (%)	0.1511	0.0418	0.2045	0.1	
		P (%)	0.0096	2.00E-04	0.0136	0.17	
		SLA (m2 g−1)	0.0011	0	0.0014	0.19	
		Thickness (mm)	0.038	0.0024	0.0492	0.36	
Gabon		Area (cm2)	26.2327	1598.5937	39.9824	0.47	
		C (%)	1.3224	3.2113	1.792	0.18	
		Ca (%)	0.1744	0.0548	0.2342	0.36	
		Dry mass (g)	0.4585	0.7355	0.8576	0.4	
		Fresh mass (g)	0.9372	5.5005	2.3453	0.27	
		Leaf water content (%)	4.6734	47.67	6.9043	0.48	0.66
		K (%)	0.1804	0.0723	0.2688	0.26	
		Mg (%)	0.0803	0.0113	0.1061	0.41	
		N (%)	0.3009	0.1669	0.4085	0.51	
		P (%)	0.0082	1.00E-04	0.0113	0.59	
		SLA (m2 g−1)	0.0019	0	0.0028	0.22	
		Thickness (mm)	0.05	0.0052	0.0723	0.18	
Malaysia	**50% smallest trees out**	Amax (µmol m−2 s−1)	4.2786	29.9285	5.4707	0.44	
		Area (cm2)	136.9901	57104.3867	238.9652	0.06	
		Asat (µmol m−2 s−1)	2.0399	7.1341	2.671	0.33	0.90	0.80
		C (%)	1.6566	5.1133	2.2613	0.31	
		Ca (%)	0.3117	0.4211	0.649	0.33	
		Dry mass (g)	1.3783	4.2579	2.0635	0.11	

Location	Trait					
	Fresh mass (g)	3.7924	50.5755	7.1116	0.04	
	Leaf water content (%)	3.5339	24.5958	4.9594	0.18	
	K (%)	0.3152	0.2012	0.4485	0.2	
	Mg (%)	0.0926	0.0186	0.1363	0.38	
	N (%)	0.2807	0.155	0.3938	0.14	
	P (%)	0.0218	0.0016	0.0399	0.3	
	SLA (m2 g−1)	0.0017	0	0.0024	0.11	
	Thickness (mm)	0.0586	0.0118	0.1086	0.23	
Brazil -NX	Amax (µmol m−2 s−1)	3.2298	19.8841	4.4592	0.36	
	Area (cm2)	19.3015	957.0967	30.937	0.13	
	Asat (µmol m−2 s−1)	1.6448	4.5215	2.1264	0.54	
	Ca (%)	0.0718	0.014	0.1185	0.38	
	Dry mass (g)	0.312	0.2804	0.5295	0.15	
	Fresh mass (g)	0.6595	1.0529	1.0261	0.21	
	Leaf water content (%)	3.8178	24.3504	4.9346	0.12	0.92
	K (%)	0.0755	0.01	0.1001	0.03	
	Mg (%)	0.0226	0.001	0.0309	0.44	
	N (%)	0.1915	0.0579	0.2407	0.49	
	P (%)	0.0196	7.00E-04	0.0262	0.52	
	SLA (m2 g−1)	0.0012	0	0.0017	0.38	
	Thickness (mm)	0.0288	0.0014	0.0379	0.55	
Peru	Amax (µmol m−2 s−1)	3.0672	15.6312	3.9536	0.25	
	Area (cm2)	90.8151	24976.1136	158.0383	0.38	
	Asat (µmol m−2 s−1)	1.5203	3.9208	1.9801	0.43	
	C (%)	1.4446	3.714	1.9272	0.35	
	Ca (%)	0.1586	0.06	0.2449	0.64	
	Dry mass (g)	1.4424	10.7439	3.2778	0.26	0.80
	Fresh mass (g)	1.256	3.6084	1.8996	0.2	
	Leaf water content (%)	8.2209	138.2141	11.7564	0.36	
	K (%)	0.1245	0.0331	0.182	0.21	
	Mg (%)	0.0663	0.0083	0.0911	0.39	
	N (%)	0.2925	0.1532	0.3914	0.37	
	P (%)	0.0211	9.00E-04	0.0298	0.48	

Region	Trait					
	SLA (m2 g−1)	0.0037	1.00E-04	0.0077	0.42	
	Thickness (mm)	0.0629	0.009	0.0948	0.65	
Brazil -ST	Area (cm2)	57.1532	10108.7154	100.5421	0.06	
	C (%)	1.3873	3.716	1.9277	0.15	
	Ca (%)	0.2668	0.1348	0.3672	0.11	
	Dry mass (g)	0.3902	0.2786	0.5278	0.08	
	Fresh mass (g)	1.055	2.2293	1.4931	0.24	
	Leaf water content (%)	4.5129	39.5954	6.2925	0.18	0.70
	K (%)	0.1102	0.0203	0.1424	0.3	
	Mg (%)	0.0492	0.0041	0.064	0.29	
	N (%)	0.4757	0.4136	0.6431	0.24	
	P (%)	0.0218	0.0011	0.0331	0.26	
	SLA (m2 g−1)	0.002	0	0.0027	0.28	
	Thickness (mm)	0.0471	0.005	0.0708	0.33	
Ghana	Amax (µmol m−2 s−1)	2.5583	10.5358	3.2459	0.22	
	Area (cm2)	45.4496	4574.3599	67.634	0.38	
	Asat (µmol m−2 s−1)	1.316	3.3803	1.8386	0.14	
	Ca (%)	0.4254	0.4098	0.6402	0.49	
	K (%)	0.3127	0.1794	0.4235	0.25	
	Mg (%)	0.0924	0.0142	0.1193	0.27	0.63
	N (%)	0.2873	0.1378	0.3713	0.5	
	P (%)	0.019	6.00E-04	0.0246	0.34	
	SLA (m2 g−1)	0.0015	0	0.002	0.15	
	Thickness (mm)	0.042	0.0034	0.0583	0.09	
Australia	Area (cm2)	9.9697	283.1659	16.8275	0.14	
	Asat (µmol m−2 s−1)	0.793	1.0891	1.0436	0.2	
	C (%)	1.2066	2.3966	1.5481	0.36	
	Ca (%)	0.2374	0.0813	0.2851	0.28	
	K (%)	0.1481	0.0374	0.1935	0.18	0.47
	Mg (%)	0.0638	0.0082	0.0905	0.11	
	N (%)	0.1712	0.0497	0.2229	0.13	
	P (%)	0.0091	2.00E-04	0.0124	0.24	
	SLA (m2 g−1)	0.0012	0	0.0015	0.26	

	Thickness (mm)	0.0417	0.0027	0.0523	0.29	
	Area (cm2)	23.7815	888.0666	29.8004	0.19	
	C (%)	1.4533	3.63	1.9052	0.26	
	Ca (%)	0.1787	0.0619	0.2488	0.51	
	Dry mass (g)	0.3498	0.2167	0.4655	0.18	
	Fresh mass (g)	0.9271	2.1663	1.4718	0.16	
Gabon	Leaf water content (%)	5.4768	54.9805	7.4149	0.47	0.79
	K (%)	0.1714	0.0626	0.2503	0.15	
	Mg (%)	0.0871	0.0118	0.1084	0.55	
	N (%)	0.2535	0.1131	0.3363	0.61	
	P (%)	0.0103	2.00E-04	0.0152	0.43	
	SLA (m2 g−1)	0.002	0	0.0034	0.4	
	Thickness (mm)	0.0463	0.0038	0.0619	0.26	

Brazil -NX: Nova Xavantina; Brazil -ST: Santarem. MAE: Mean Absolute Error; MSE: Mean Square Error; RMSE: Root mean square error.

Table S5. Statistical results on the test data for the models fitted per region for each functional trait.

Locations	Trait	MAE	MSE	RMSE	R^2
Australia	Area (cm2)	7.89E+00	1.64E+02	1.28E+01	0.35
	Asat (µmol m−2 s−1)	7.51E-01	1.02E+00	1.01E+00	0.03
	C (%)	9.67E-01	1.87E+00	1.37E+00	0.34
	Ca (%)	1.87E-01	5.74E-02	2.40E-01	0.33
	K (%)	1.23E-01	3.50E-02	1.87E-01	0.06
	Mg (%)	6.16E-02	1.02E-02	1.01E-01	0.12
	N (%)	1.53E-01	4.80E-02	2.19E-01	0.17
	P (%)	7.60E-03	1.00E-04	1.07E-02	0.21
	SLA (m2 g−1)	9.00E-04	0.00E+00	1.30E-03	0.25
	Thickness (mm)	3.47E-02	2.30E-03	4.77E-02	0.21
Gabon	Area (cm2)	2.97E+01	2.07E+03	4.55E+01	0.11
	C (%)	1.26E+00	2.95E+00	1.72E+00	0.22
	Ca (%)	1.55E-01	4.51E-02	2.12E-01	0.39
	Dry mass (g)	5.92E-01	1.72E+00	1.31E+00	0.22
	Fresh mass (g)	1.06E+00	3.39E+00	1.84E+00	0.11
	Leaf water content (%)	5.05E+00	4.34E+01	6.59E+00	0.38
	K (%)	1.87E-01	7.25E-02	2.69E-01	0.24
	Mg (%)	6.48E-02	7.20E-03	8.51E-02	0.52
	N (%)	2.88E-01	1.56E-01	3.95E-01	0.50
	P (%)	1.14E-02	3.00E-04	1.70E-02	0.60
	SLA (m2 g−1)	1.90E-03	0.00E+00	2.80E-03	0.15
	Thickness (mm)	4.70E-02	3.80E-03	6.14E-02	0.23
Ghana	Amax (µmol m−2 s−1)	2.19E+00	7.71E+00	2.78E+00	0.49
	Area (cm2)	3.73E+01	2.94E+03	5.42E+01	0.29
	Asat (µmol m−2 s−1)	1.09E+00	1.86E+00	1.36E+00	0.36
	Ca (%)	3.99E-01	5.03E-01	7.09E-01	0.53
	K (%)	2.85E-01	1.61E-01	4.01E-01	0.23
	Mg (%)	9.77E-02	1.81E-02	1.35E-01	0.15
	N (%)	2.77E-01	1.57E-01	3.96E-01	0.52
	P (%)	1.61E-02	5.00E-04	2.15E-02	0.47
	SLA (m2 g−1)	1.30E-03	0.00E+00	1.60E-03	0.14
	Thickness (mm)	2.96E-02	1.60E-03	4.02E-02	0.22
Malaysia	Amax (µmol m−2 s−1)	3.86E+00	2.58E+01	5.08E+00	0.48
	Area (cm2)	1.33E+02	5.64E+04	2.38E+02	0.11
	Asat (µmol m−2 s−1)	1.70E+00	4.55E+00	2.13E+00	0.36
	C (%)	1.57E+00	4.78E+00	2.19E+00	0.38
	Ca (%)	2.96E-01	2.78E-01	5.27E-01	0.50
	Dry mass (g)	1.57E+00	9.55E+00	3.09E+00	0.07
	Fresh mass (g)	4.03E+00	7.70E+01	8.77E+00	0.03
	Leaf water content (%)	3.89E+00	2.85E+01	5.34E+00	0.24
	K (%)	2.96E-01	1.90E-01	4.35E-01	0.28
	Mg (%)	9.84E-02	1.86E-02	1.36E-01	0.31
	N (%)	2.27E-01	1.29E-01	3.58E-01	0.27
	P (%)	2.08E-02	1.30E-03	3.64E-02	0.34
	SLA (m2 g−1)	1.70E-03	0.00E+00	2.70E-03	0.06
	Thickness (mm)	5.05E-02	8.40E-03	9.16E-02	0.31

Brazil -NX	Amax (μmol m−2 s−1)	2.40E+00	1.06E+01	3.26E+00	0.42
	Area (cm2)	1.54E+01	4.50E+02	2.12E+01	0.08
	Asat (μmol m−2 s−1)	1.48E+00	3.60E+00	1.90E+00	0.52
	Ca (%)	5.70E-02	5.10E-03	7.15E-02	0.49
	Dry mass (g)	2.12E-01	1.16E-01	3.40E-01	0.38
	Fresh mass (g)	5.42E-01	8.21E-01	9.06E-01	0.31
	Leaf water content (%)	2.91E+00	1.50E+01	3.88E+00	0.07
	K (%)	5.81E-02	6.00E-03	7.74E-02	0.07
	Mg (%)	2.32E-02	9.00E-04	3.05E-02	0.46
	N (%)	1.63E-01	4.22E-02	2.05E-01	0.52
	P (%)	1.49E-02	4.00E-04	1.89E-02	0.68
	SLA (m2 g−1)	8.00E-04	0.00E+00	1.10E-03	0.54
	Thickness (mm)	2.26E-02	9.00E-04	3.00E-02	0.66
Peru	Amax (μmol m−2 s−1)	2.43E+00	9.28E+00	3.05E+00	0.36
	Area (cm2)	1.10E+02	5.90E+04	2.43E+02	0.18
	Asat (μmol m−2 s−1)	1.36E+00	3.17E+00	1.78E+00	0.38
	C (%)	1.27E+00	3.19E+00	1.79E+00	0.47
	Ca (%)	1.25E-01	3.41E-02	1.85E-01	0.69
	Dry mass (g)	1.53E+00	1.09E+01	3.30E+00	0.09
	Fresh mass (g)	1.01E+00	1.97E+00	1.40E+00	0.2
	Leaf water content (%)	8.07E+00	1.29E+02	1.13E+01	0.34
	K (%)	1.03E-01	1.74E-02	1.32E-01	0.3
	Mg (%)	5.52E-02	6.20E-03	7.89E-02	0.46
	N (%)	2.52E-01	1.14E-01	3.37E-01	0.44
	P (%)	2.18E-02	8.00E-04	2.89E-02	0.49
	SLA (m2 g−1)	2.70E-03	0.00E+00	5.10E-03	0.32
	Thickness (mm)	5.66E-02	9.10E-03	9.53E-02	0.64
Brazil -ST	Area (cm2)	4.31E+01	5.68E+03	7.53E+01	0.04
	C (%)	1.36E+00	3.72E+00	1.93E+00	0.07
	Ca (%)	2.36E-01	8.75E-02	2.96E-01	0.15
	Dry mass (g)	3.86E-01	3.18E-01	5.64E-01	0.25
	Fresh mass (g)	1.07E+00	3.39E+00	1.84E+00	0.18
	Leaf water content (%)	4.22E+00	3.48E+01	5.90E+00	0.05
	K (%)	1.08E-01	2.32E-02	1.52E-01	0.29
	Mg (%)	4.95E-02	4.00E-03	6.32E-02	0.28
	N (%)	3.26E-01	1.82E-01	4.27E-01	0.30
	P (%)	2.06E-02	1.00E-03	3.17E-02	0.47
	SLA (m2 g−1)	1.80E-03	0.00E+00	2.20E-03	0.29
	Thickness (mm)	4.37E-02	4.40E-03	6.62E-02	0.42

Brazil -NX: Nova Xavantina; Brazil -ST: Santarem. MAE: Mean Absolute Error; MSE: Mean Square Error; RMSE: Root mean square error.

References:

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