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Contrasting photosynthetic characteristics of forest vs. savanna species (Far North Queensland, Australia)

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Table S1. List of species measured with Site code (Table 1) and Φ (Table S2) for the tropical moist forest species.

Site	Type	*Species*	Φ (forest species)	*n*
KBL-01	Forest	*Alangium villosum*	Sub-canopy	4
KBL-01	Forest	*Aleurites rockinghamensis*	Tall pioneer	4
KBL-03	Forest	*Apodytes brachystylis*	Sub-canopy	4
KCR-01	Forest	*Ardisia brevipedata*	Sub-canopy	4
CTC-01	Forest	*Argyrodendron peralatum*	Upper canopy	4
KBL-03	Forest	*Beilschmiedia tooram*	Upper canopy	1
CTC-01	Forest	*Cardwellia sublimis*	Tall pioneer	4
KCR-01	Forest	*Cardwellia sublimis*	Tall pioneer	5
KBL-01	Forest	*Castanospora alphandii*	Upper canopy	1
CTC-01	Forest	*Cleistanthus myrianthus*	Upper canopy	3
DCR-02	Savanna	*Corymbia citriodora*		3
DCR-02	Savanna	*Corymbia clarksoniana*		3
DCR-01	Savanna	*Corymbia intermedia*		1
KBL-02	Savanna	*Corymbia intermedia*		4
KBL-01	Forest	*Elaeocarpus grandis*	Tall pioneer	1
KBL-03	Forest	*Elaeocarpus largiflorens*	Upper canopy	4
DCR-02	Savanna	*Eucalyptus portuensis*		4
KCR-01	Forest	*Eupomatia laurina*	Sub-canopy	5
CTC-01	Forest	*Haplostichanthus ramiflorus*	Sub-canopy	4
KBL-03	Forest	*Litsea leefeana*	Tall pioneer	1
DCR-01	Savanna	*Lophostemon suaveolens*		3
KBL-02	Savanna	*Lophostemon suaveolens*		4
CTC-01	Forest	*Mallotus mollissimus*	Small pioneer	4
KBL-01	Forest	*Neisosperma poweri*	Sub-canopy	4
KBL-01	Forest	*Neolitsea dealbata*	Small pioneer	4
KBL-03	Forest	*Neolitsea dealbata*	Small pioneer	4
KCR-01	Forest	*Neolitsea dealbata*	Small pioneer	6
DCR-01	Savanna	*Planchonia careya*		6
KCR-01	Forest	*Polyscias elegans*	Tall pioneer	4
CTC-01	Forest	*Pseuduvaria froggattii*	Sub-canopy	4
KBL-03	Forest	*Sloanea australis*	Upper canopy	4
KBL-03	Forest	*Symplocos hayesii*	Sub-canopy	4
KBL-03	Forest	*Synima cordierorum*	Sub-canopy	1
KCR-01	Forest	*Toechima erythrocarpum*	Sub-canopy	4
KBL-03	Forest	*Wilkiea angustifolia*	Sub-canopy	5
		Total number of $A \leftrightarrow C_i$ curves		**125**
		Number of Site + Species combinations with replicates ≥ 3		**28**

Table S2. Plant functional type (Φ) assigned to the forest species. The classification assigned to each species is based on light requirement and adult stature.

Plant functional type (Φ)	**Description**
Small pioneer	Small stature pioneer, light demanding
Sub-canopy	Sub canopy, shade tolerant
Tall pioneer	Tall pioneer, light demanding
Upper-canopy	Upper canopy, shade tolerant, but well adapted to sunlit conditions

Table S3: Kendall's rank-order (tau, τ) correlations between site variables (elevation above sea level E_V, mean annual temperature T_A, mean annual precipitation P_A, soil pH, soil exchangeable cations, soil extractable phosphorus) and selected leaf traits (photosynthetic capacity, levels of nitrogen and phosphorus – all on an area basis). Soil values represent the top 0.3 m of soil horizon.

	$A_{max,a}$		Leaf $[N]_a$		Leaf $[P]_a$	
Site variable	Kendall's τ	p value	Kendall's τ	p value	Kendall's τ	p value
E_v (m)	**-0.197**	**0.0027**	**-0.241**	**0.0002**	**-0.199**	**0.0025**
T_A (°C)	**0.144**	**0.0318**	**0.212**	**0.0016**	**0.163**	**0.0155**
P_A (m)	0.064	0.3295	0.022	0.7404	-0.004	0.9490
pH	0.111	0.0914	0.166	0.0114	0.098	0.1362
$[Al]_e$ ($mmol_{eq}\ kg^{-1}$)	**-0.214**	**0.0011**	**-0.132**	**0.0442**	**-0.137**	**0.0378**
$[Ca]_e$ ($mmol_{eq}\ kg^{-1}$)	-0.010	0.8761	0.073	0.2690	0.014	0.8324
$[K]_e$ ($mmol_{eq}\ kg^{-1}$)	**-0.245**	**0.0002**	**-0.159**	**0.0169**	**-0.200**	**0.0027**
$[Mg]_e$ ($mmol_{eq}\ kg^{-1}$)	**0.206**	**0.0017**	**0.211**	**0.0013**	**0.148**	**0.0246**
$[Na]_e$ ($mmol_{eq}\ kg^{-1}$)	0.005	0.9432	0.048	0.4640	-0.029	0.6550
CEC ($mmol_{eq}\ kg^{-1}$)	-0.022	0.7418	-0.029	0.6656	-0.004	0.9590
$[P]_{ex}$ ($\mu g\ g^{-1}$)	0.087	0.1845	0.013	0.8431	0.044	0.5024

Table S4. Results of standardised major axis (SMA) bivariate relationships testing the null hypothesis that there was no difference between Forest and Savanna trees in slope (LR, Likelihood ratio statistic), intercept or axis shift (Wald statistic). For each bivariate relationship the assumption of linearity, for the dataset as a whole, was tested using Pearson's correlation (r). The dataset here excludes the four outlying points identified on Figure 2a.

		Test for linear relationship			Significance of difference between Vegetation classes in					
					Slope		Elevation		Shift	
Response	Bivariate	df	r	*p*	LR	*p*	Wald	*p*	Wald	*p*
$[P]_a$ ↔	$[N]_a$	103	0.89	**<0.0001**	7.58	**0.0059**	NA	NA	NA	NA
$[P]_m$ ↔	$[N]_m$	103	0.90	**<0.0001**	3.41	0.0646	3.74	0.053	19.10	**<0.0001**
$[N]_a$ ↔	M_a	103	0.63	**<0.0001**	13.83	**0.0002**	NA	NA	NA	NA
$[P]_a$ ↔	M_a	103	0.53	**<0.0001**	3.08	0.0794	10.00	**0.002**	45.74	**<0.0001**
$A_{max,a}$ ↔	$[N]_a$	103	0.67	**<0.0001**	16.09	**<0.0001**	NA	NA	NA	NA
$A_{max,a}$ ↔	$[P]_a$	103	0.63	**<0.0001**	3.98	**0.0459**	NA	NA	NA	NA
$A_{max,a}$ ↔	M_a	103	0.55	**<0.0001**	0.02	0.8805	0.19	0.659	63.41	**<0.0001**
$A_{max,m}$ ↔	$[N]_m$	103	0.69	**<0.0001**	0.77	0.3809	40.36	**<0.0001**	4.33	**0.037**
$A_{max,m}$ ↔	$[P]_m$	103	0.70	**<0.0001**	0.02	0.8976	26.28	**<0.0001**	2.40	0.121
$A_{max,m}$ ↔	M_a	107	-0.23	0.017	7.53	**0.0061**	NA	**NA**	NA	NA
$DM:H_2O$ ↔	M_a	107	0.62	**<0.0001**	7.84	**0.0051**	NA	NA	NA	NA
d ↔	M_a	107	0.24	**0.0113**	21.52	**<0.0001**	NA	NA	NA	NA
ρ ↔	M_a	104	0.82	**<0.0001**	5.58	**0.0181**	NA	NA	NA	NA
A_N ↔	M_a	103	0.34	**0.0004**	0.24	0.6249	0.86	0.353	58.44	**<0.0001**

Table S5 Kendall's rank-order (tau, τ) correlations between site variables (elevation above sea level E_V, mean annual temperature T_A, mean annual precipitation P_A, soil pH, soil exchangeable cations, soil extractable phosphorus) and standardised residual terms from the preferred mixed effects model (Eq. 2, Table 4). Soil values represent the top 0.3 m of soil horizon.

Site variable	Kendall's τ	*p* value
E_v (m)	0.002	0.974
T_A (°C)	-0.011	0.877
P_A (m)	-0.009	0.894
pH	-0.042	0.550
$[Al]_e$ ($mmol_{eq}\ kg^{-1}$)	-0.053	0.446
$[Ca]_e$ ($mmol_{eq}\ kg^{-1}$)	-0.018	0.794
$[K]_e$ ($mmol_{eq}\ kg^{-1}$)	-0.087	0.221
$[Mg]_e$ ($mmol_{eq}\ kg^{-1}$)	0.003	0.966
$[Na]_e$ ($mmol_{eq}\ kg^{-1}$)	-0.065	0.354
CEC ($mmol_{eq}\ kg^{-1}$)	-0.051	0.462
$[P]_{ex}$ ($\mu g\ g^{-1}$)	0.051	0.465

Table S6: Output of a comparative linear mixed effects model (after Eq. 2) with leaf traits expressed on a mass basis: fixed effects (top) and random effects (bottom). The top section shows fixed effect parameter estimates and associated standard error, degrees of freedom, test statistic and associated *p*-value. The final 'optimal' model is compared against a simpler 'null' model that includes only vegetation class (Ⅳ) in the fixed component, but has an identical random term of Species nested within Site. Continuous explanatory variables were centred on their respective means.

	Final model					**Null model**				
Fixed effect	Estimate	S.E.	DF	t value	*p value*	Estimate	S.E.	DF	t value	*p value*
Forest (with other variables at mean value)	210.04	14.81	71	14.181	**<0.0001**	262.78	55.87	74	4.703	**<0.0001**
Savanna (Vegetation contrast)	86.35	28.33	5	3.048	**0.0285**	-30.96	90.58	5	-0.342	0.7464
$Leaf[N]_m$	6.95	2.14	71	3.252	**0.0018**					
$Leaf[P]_m$	104.52	43.46	71	2.405	**0.0188**					
$Leaf[N]_m : Leaf[P]_m$	5.95	2.71	71	2.198	**0.0312**					

Random effect	Variance	% of total		Variance	% of total
Intercept variance: Among sites	0	0.0%		10,328	38.8%
Intercept variance: Among species	2,513	32.4%		11,645	43.8%
Residual (within species, within sites)	5,251	67.6%		4,627	17.4%
	7,763	100.0%		26,600	100.0%
AIC			1,228		1,275
Likelihood ratio test			-606		-632

Figure S1. Kernel density plot showing smoothed probability distributions of leaf mass per unit area (g m^{-2}) for each plant functional type.

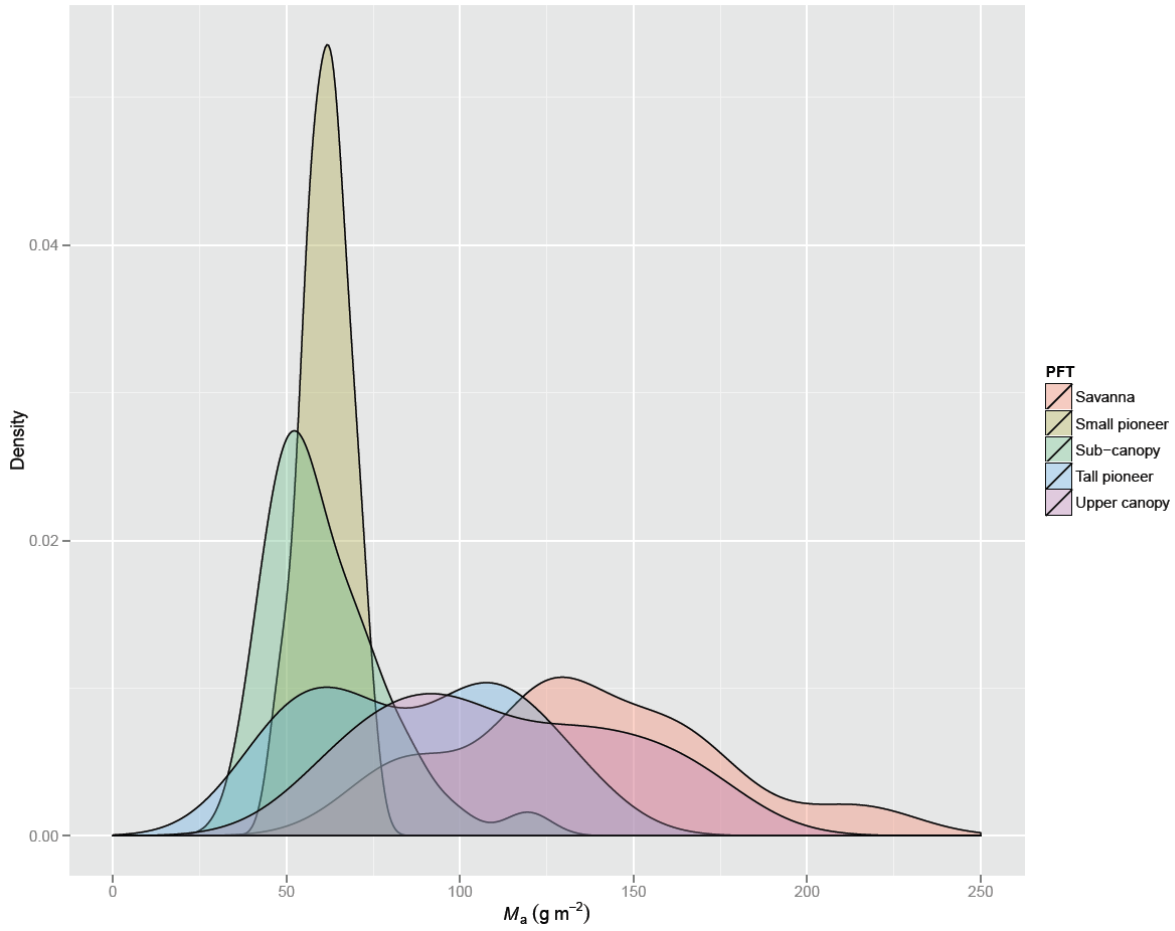

Figure S2. Pair-wise plot of response and explanatory variables. The upper panel contains estimated pair-wise correlations and the font size is proportional to the absolute value of the estimated correlation coefficient. Significance codes: *** <0.001, ** <0.01, * <0.05, . <0.01. The diagonal panel contains histograms and the lower panel scatterplots with a local regression smoother added to aid visual interpretation. The selected variables are photosynthetic capacity on an area basis as response with six continuous explanatory variables (spanning leaf morphology and nutrient levels). Trait units are $A_{max,a}$ (μmol CO_2 m^{-2} s^{-1}), Maximum conductance (mol m^{-2} s^{-1}), Leaf mass per unit area (g m^{-2}), Leaf dry matter content (g g^{-1}), Leaf thickness (μm), Total leaf nitrogen per unit area (g m^{-2}), Total leaf phosphorus per unit area (mg m^{-2}).

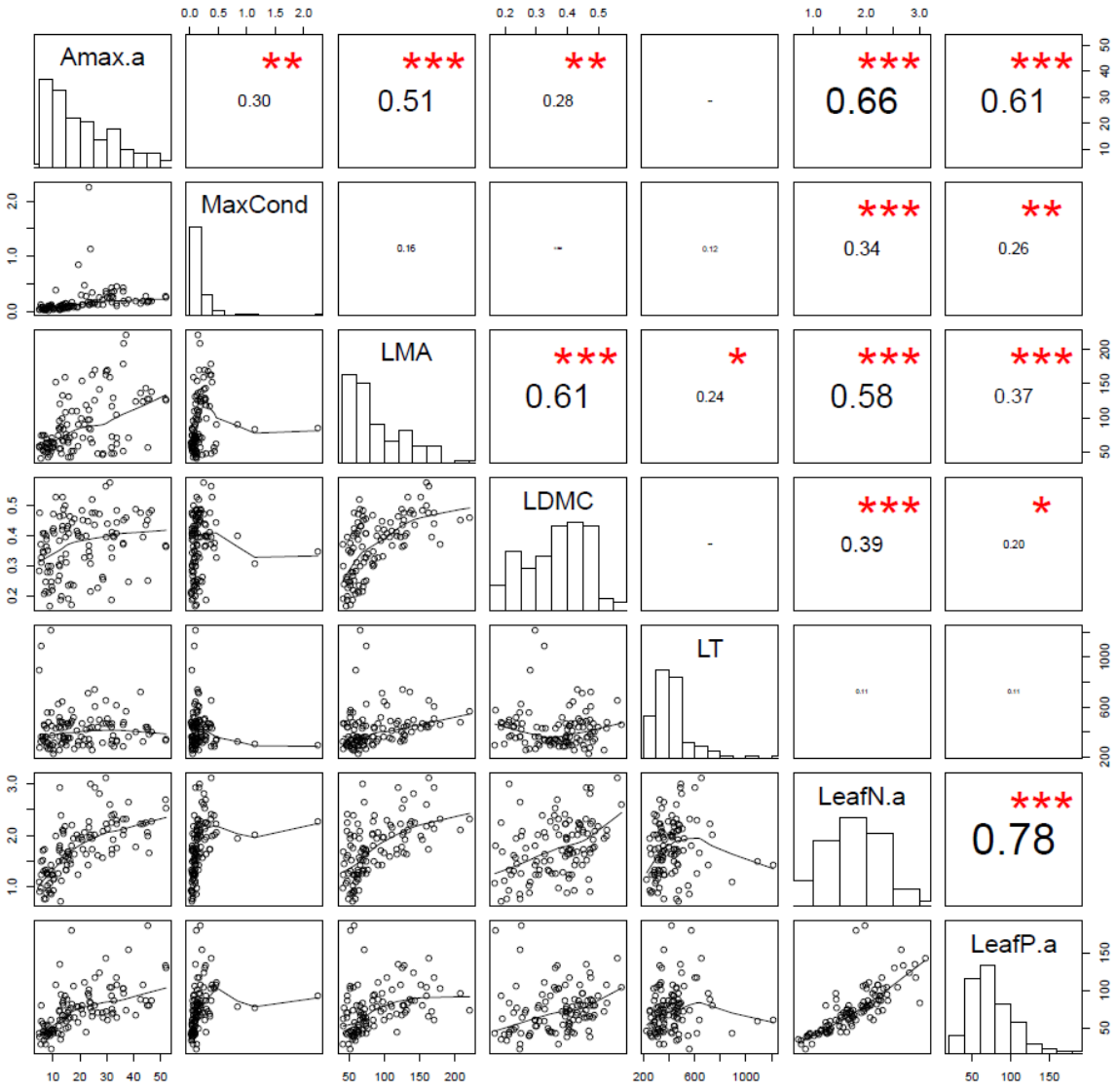

Figure S3: Model validation graphs for the random intercept mixed effects model (Eq. 2). Standardised residuals are plotted against fitted values and each of the explanatory factors and variables used in the model's fixed component.

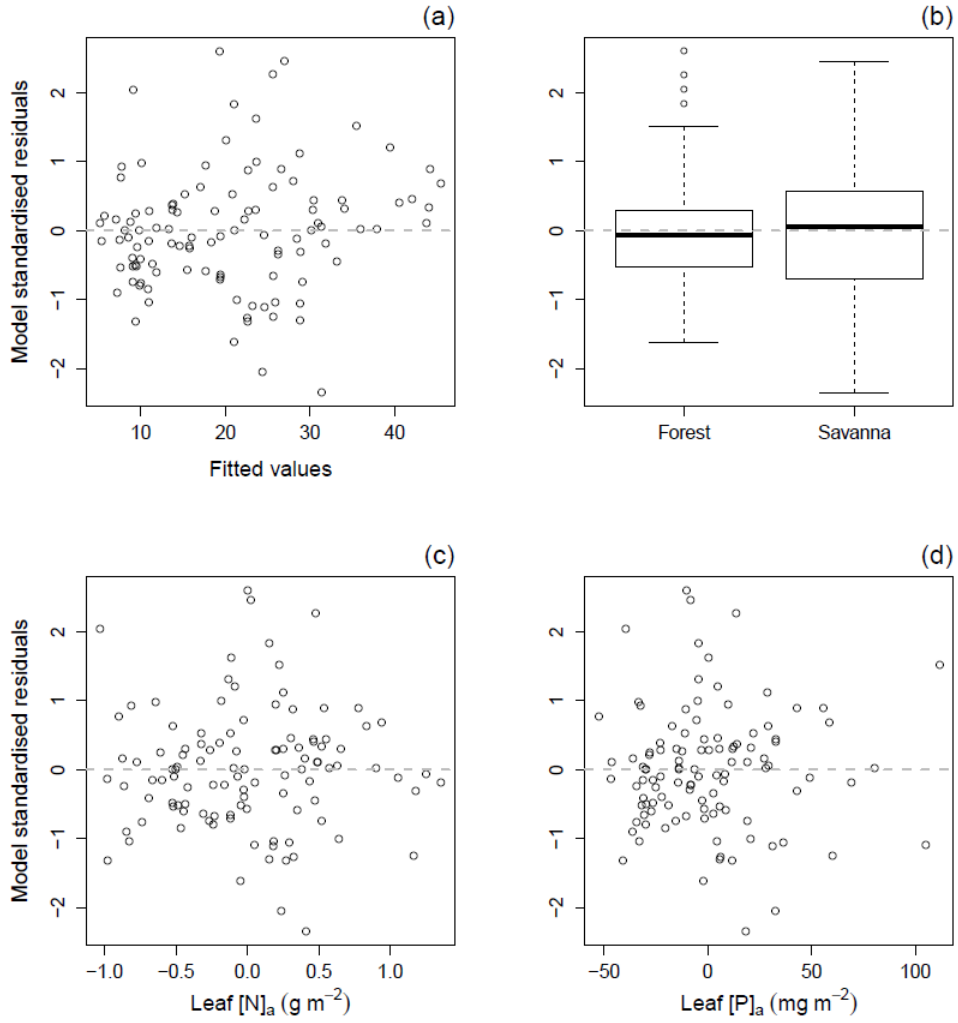

Figure S4 Scatterplots of model standardised residuals (Eq. 2, Table 4) and selected site variables of elevation, temperature and soil conditions. Corresponding Kendall's rank-order (tau, τ) correlations are shown in Table S5.