

Supplementary Materials

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Neighbourhood species richness reduces crown asymmetry of subtropical trees in
sloping terrain

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Supporting methods

1. Neighbourhood pressure (NP)

In general, to calculate neighbourhood pressure, a measure of the size of the neighbour is divided by the distance to the target tree. Size of the neighbour can be expressed as height (Umeki, 1995), diameter at breast height (DBH; Brisson, 2001; Seidel et al., 2011) or crown area (CPA; Schröter et al., 2012; Vovides et al., 2018).

However, we observed inaccuracies when applying these methods to a young plantation with steep slopes: When using CPA as size, we found big differences between fast and slow growing species, where a slow growing tree could present higher CPA than a taller tree (supplementary Figure S1a). When using height, we could see how the topography can situate a smaller tree in the same canopy layer than a taller tree situated in a downhill position (supplementary Figure S1b).

For this study, we developed an equation to scale the NP depending if both trees are at the same canopy level. The [canopy level index](#) (c_{li} , Eq. 1) is a combination between a Gaussian and a Sigmoid function, where a modifies the height of the Gaussian curve's peak, b the width of the Gaussian bell, c the peak of the Sigmoid's curve, and d the position of the centre of the bell. X represents the height difference, calculated as (neighbour altitude + neighbour height) - (target altitude + target height)

$$C_{li} = \frac{a}{1 + e^{-(x+b)}} \cdot e^{-x^2/2 \cdot c^2} + d$$

We look for a function where, if the height difference (taking into account the topography) is 0, it is close to the maximum value (1), if it is negative the effect arrives to 0, and if the positive difference is really high the effect is lower because the target tree could grow in the understorey. We used the parameters $a = 0.5$, $b = 2$, $c = 10$, $d = 1$. supplementary Figure S2 shows the curve of the c_{li} .

Supporting tables

Table S1. Plot characteristics and the number of target trees that were scanned and analysed in a given study year.

Species names follow nomenclature in “The Flora of China” (<http://flora.huh.harvard.edu/china>).

Species Richness	Species	Plot ID	2012	2013	2014	2015	2016	2019	Mean slope (°)
Monoculture	<i>Castanea henryi</i>	E34	13	11	11	11	11	7	12.2
Monoculture	<i>Castanea henryi</i>	F34	15	14	14	14	14	13	36.0
Monoculture	<i>Castanopsis sclerophylla</i>	G17				9		7	32.5
Monoculture	<i>Castanopsis sclerophylla</i>	L11				16	16	13	30.9
Monoculture	<i>Choerospondias axillaris</i>	L23	15	15	15	15	15	14	23.6
Monoculture	<i>Choerospondias axillaris</i>	O27	14	16	14	13	13	9	26.0
Monoculture	<i>Liquidambar formosana</i>	E24		16	16	16	16	16	35.3
Monoculture	<i>Liquidambar formosana</i>	I28		16	16	16	16	16	25.7
Monoculture	<i>Nyssa sinensis</i>	H25	14	14	14	14	13	12	36.0
Monoculture	<i>Nyssa sinensis</i>	W14			9	9	9	9	35.4
Monoculture	<i>Quercus serrata</i>	F21				15	15	16	26.8
Monoculture	<i>Quercus serrata</i>	G33					8	2	6.1
Monoculture	<i>Sapindus saponaria</i>	N11		15		15	15	14	25.8
Monoculture	<i>Sapindus saponaria</i>	R17	15	15	15	15	15	15	38.0
Monoculture	<i>Triadica sebifera</i>	N13	15	15	16	16	15	15	33.3
Monoculture	<i>Triadica sebifera</i>	N14	15	13	13	13	13	11	31.2
2-species	<i>C. axillaris</i> , <i>T. sebifera</i>	I26	11	11	10	14	14	5	37.7
2-species	<i>C. axillaris</i> , <i>T. sebifera</i>	I27	14	15		15	14	13	10.5
2-species	<i>C. henryi</i> , <i>N. sinensis</i>	C32	14	13	13	12	12	10	38.1
2-species	<i>C. henryi</i> , <i>N. sinensis</i>	F22	12	13	14	14		5	44.8
2-species	<i>C. sclerophylla</i> , <i>Q. serrata</i>	O26				16		12	31.9
2-species	<i>C. sclerophylla</i> , <i>Q. serrata</i>	P26				15	15	15	31.5
2-species	<i>L. formosana</i> , <i>S. saponaria</i>	H31		14	16	14	13	12	24.4
2-species	<i>L. formosana</i> , <i>S. saponaria</i>	T17	13	14	14	15	15	14	33.1
4-species	<i>C. henryi</i> , <i>L. formosana</i> , <i>N. sinensis</i> , <i>S. saponaria</i>	P19		88		87	87	82	39.9
4-species	<i>C. henryi</i> , <i>L. formosana</i> , <i>N. sinensis</i> , <i>S. saponaria</i>	P29		87	86	87	87	83	22.9
4-species	<i>C. sclerophylla</i> , <i>C. axillaris</i> , <i>Q. serrata</i> , <i>T. sebifera</i>	F27	74	75	79	82	85	61	33.6
4-species	<i>C. sclerophylla</i> , <i>C. axillaris</i> , <i>Q. serrata</i> , <i>T. sebifera</i>	N20	81	83		90	91	41	31.0
8-species	<i>C. henryi</i> , <i>C. sclerophylla</i> , <i>C. axillaris</i> , <i>L. formosana</i> , <i>N. sinensis</i> , <i>Q. serrata</i> , <i>S. saponaria</i> , <i>T. sebifera</i>	R16	77	75	75	76	74	66	34.0

Species Richness	Species	Plot ID	2012	2013	2014	2015	2016	2019	Mean slope (°)
8-species	<i>C. henryi</i> , <i>C. sclerophylla</i> , <i>C. axillaris</i> , <i>L. formosana</i> , <i>N. sinensis</i> , <i>Q. serrata</i> , <i>S. saponaria</i> , <i>T. sebifera</i>	S10	76	76	71	70	69	59	37.7

Table S2. Overview of mean file size (and standard deviation) in Mb for each year and plot. In addition the number of scans is given for each plot.

PLOT	Number of scans	2012	2013	2014	2015	2016	2019
E24	9		78.4 ± 0.45	83.6 ± 1.35	87.8 ± 1.01	93.5 ± 1.70	92.0 ± 1.03
E34	9	84.3 ± 0.95	87.9 ± 0.82	92.3 ± 1.14	94.3 ± 0.65	96.6 ± 0.59	97.7 ± 0.77
F21	9				80.9 ± 2.84	80.3 ± 2.45	86.6 ± 2.70
F34	9	80.9 ± 1.03	81.8 ± 0.42	86.2 ± 1.09	90.5 ± 0.71	90.1 ± 0.98	94.0 ± 0.77
G17	9						88.5 ± 3.38
G33	9					79.9 ± 0.95	80.9 ± 0.69
H25	9	84.5 ± 2.05	88.9 ± 1.82	93.7 ± 2.19	00.0 ± 0.05	95.5 ± 1.82	99.9 ± 1.07
I28	9		78.4 ± 0.48	80.8 ± 1.14	83.6 ± 1.32	85.8 ± 1.96	90.5 ± 1.46
L11	9				84.3 ± 2.46	87.9 ± 2.85	94.1 ± 3.97
L23	9	79.7 ± 0.58	81.3 ± 0.74	84.8 ± 1.41	86.4 ± 0.96	86.4 ± 0.97	92.5 ± 1.66
N11	9		76.0 ± 1.17		79.0 ± 1.05	79.3 ± 1.22	81.5 ± 0.93
N13	9	79.9 ± 1.93	81.2 ± 2.94	86.6 ± 3.45	89.0 ± 4.20	90.4 ± 2.79	95.1 ± 1.91
N14	9	77.7 ± 1.02	80.8 ± 1.82	86.1 ± 4.05	88.7 ± 3.65	89.2 ± 3.29	92.7 ± 1.15
O27	9		86.9 ± 0.73	91.4 ± 0.76		92.3 ± 0.97	92.6 ± 0.55
R17	9	78.1 ± 0.96	79.0 ± 1.23		76.7 ± 6.95		89.2 ± 0.71
W14	9			88.5 ± 0.91	89.8 ± 1.10	92.6 ± 0.77	95.2 ± 1.51
C32	9	81.1 ± 1.68	85.9 ± 2.09	90.0 ± 1.64	91.7 ± 0.60	92.1 ± 1.05	93.3 ± 1.13
F22	9	82.2 ± 1.49	85.1 ± 3.06	90.9 ± 2.65	91.2 ± 7.44		92.5 ± 1.25
H31	9		79.6 ± 1.04	83.2 ± 1.76	86.0 ± 1.42	89.4 ± 2.23	91.8 ± 0.96
I26	9	80.1 ± 0.89	80.6 ± 0.91	86.5 ± 0.93	85.7 ± 0.82	78.3 ± 7.70	91.2 ± 0.84
I27	9	74.1 ± 0.72	75.3 ± 1.38		78.1 ± 1.36	79.8 ± 1.35	83.1 ± 1.68
O26	9						95.3 ± 1.58
P26	9				81.4 ± 1.62	84.0 ± 1.91	91.9 ± 3.29
T17	9	76.2 ± 0.41	80.0 ± 1.33	83.9 ± 1.00	88.3 ± 1.40	89.7 ± 0.61	92.3 ± 0.92
F27	16	81.5 ± 0.78	82.3 ± 1.33	86.9 ± 1.45	87.4 ± 1.55	89.0 ± 1.53	93.5 ± 1.38
N20	16	76.5 ± 1.62	79.4 ± 1.67		86.8 ± 2.11	87.5 ± 0.94	89.9 ± 1.08

P19	16		78.8 ± 1.87		85.5 ± 2.14	88.8 ± 1.96	91.7 ± 0.70
P29	16		78.7 ± 1.80	82.0 ± 1.75	83.8 ± 1.92	87.3 ± 1.91	90.4 ± 2.34
R16	16	82.1 ± 2.23	84.5 ± 2.86	88.9 ± 3.56	86.9 ± 1.23	93.8 ± 2.02	96.0 ± 1.11
S10	16	79.1 ± 1.00	82.9 ± 0.91	88.2 ± 1.23	90.8 ± 1.93	91.9 ± 1.24	94.3 ± 1.28

Table S3. Technical specification of the three FARO scanners based on the technical fact sheets by FARO (Korntal-Münchingen, Germany)

Parameters	FARO Photon Scanner	FARO Focus 3D S120	FARO Focus X130
Wavelength	785 nm	905 nm	1550 nm
Step size (V/H)	0.009° / 0.009°	0.009° / 0.009°	0.009° / 0.009°
Range	0.6 – 120m	0.6 – 120m	0.6m – 130m
Field of view (V/H)	320° / 360°	305° / 360°	300° / 360°
Accuracy	± 2 mm	± 2 mm	± 2 mm
Speed	122,000-976,000 points/s	122,000-976,000 points/s	122,000-976,000 points/s
Weight	14.5 kg	5.0 kg	5.2 kg

Table S4. Model comparison using different calculations of neighbourhood pressure index. NP refers to the neighbourhood pressure calculated as described in the supporting methods, VNA refers to the vector of neighbourhood asymmetry (Brisson, 2001; Brisson & Reynolds, 1994). SE: standard error; df: degrees of freedom; SD: standard deviation

	p			p	
MT	0.0609	. [+]	MT	0.0314	. [+]
TH	1.36E-05	*** [+]	TH	1.73E-05	*** [+]
NP	2.20E-16	*** [+]	VNA	2.20E-16	*** [+]
NSR	0.0076	** [-]	NSR	0.0512	. [-]
MT*NSR	0.0375	* [-]	MT*NSR	0.0130	* [-]

	NP	VNA
Marginal R ²	0.606	0.593
Conditional R ²	0.854	0.850
AIC	-4325	-4190

Supporting figures

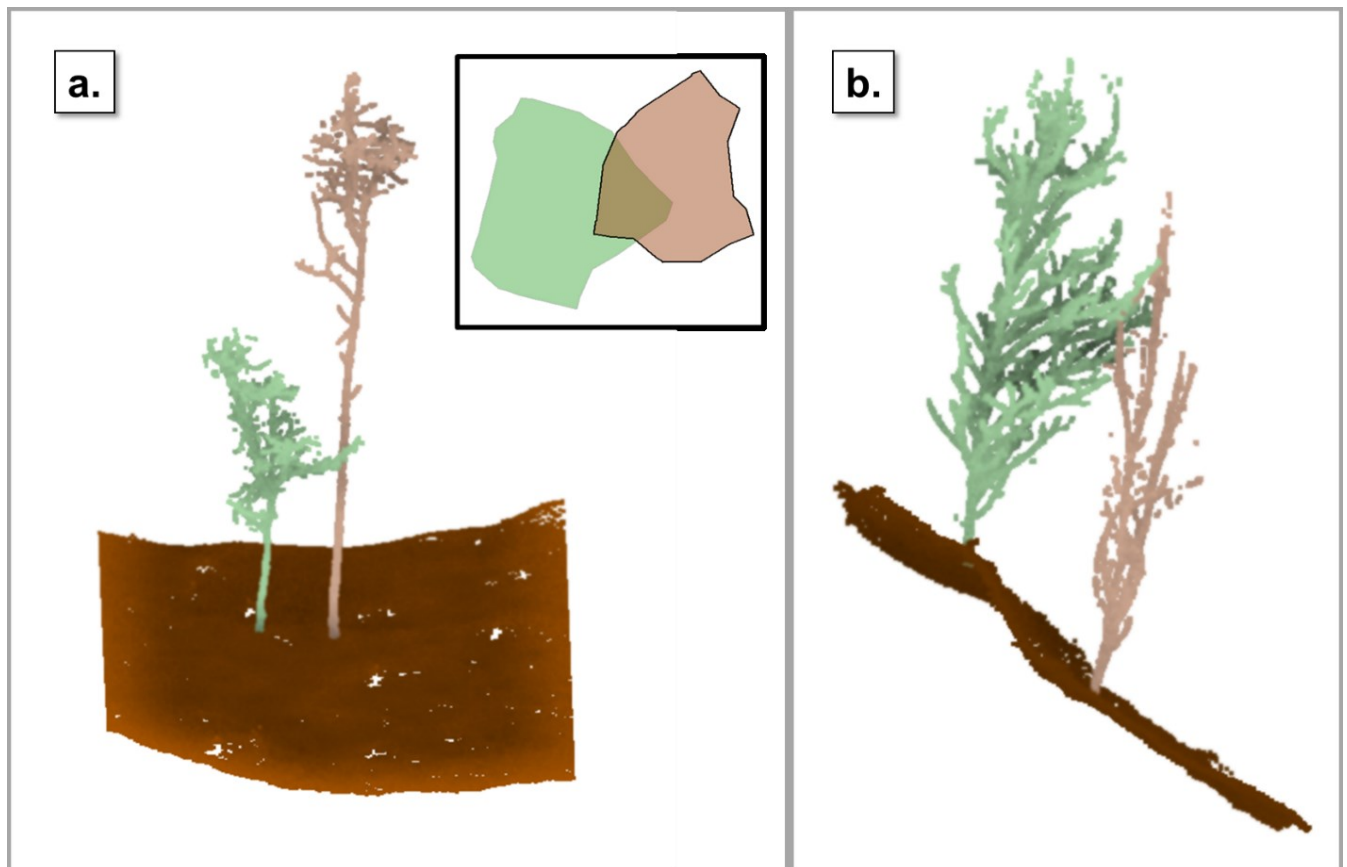


Figure S1. Representation of possible inaccuracies when using (a) crown projection area or (b) height as size measurement for the neighbourhood pressure index. (a) shows in green a target tree with CPA = 4.5 m² and in coral its neighbour with CPA = 3.5 m². (b) shows in green a target tree situated in an uphill location with height = 5.5 m, and in coral its neighbour with height = 5.5m. Brown represents the terrain.



Figure S2. Curve of the function for the canopy level index (cli). X axis represents the height difference between the neighbour and the target tree, including the altitude. Y axis would be the result to apply the cli formula to that difference.

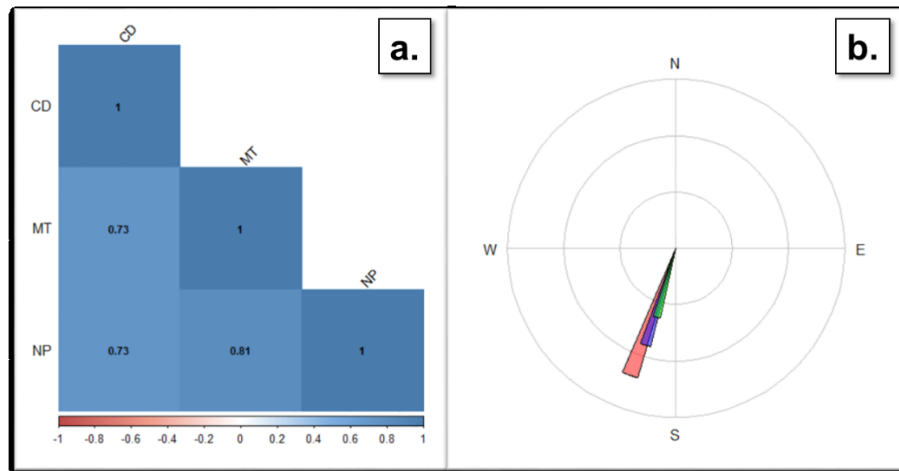


Figure S3. Correlations between the direction of crown displacement (CD), microtopography (MT) and neighbourhood pressure (NP) (a) and mean direction of CD (red), NP (blue) and MT (green) estimated with the Rayleigh's test for circular data

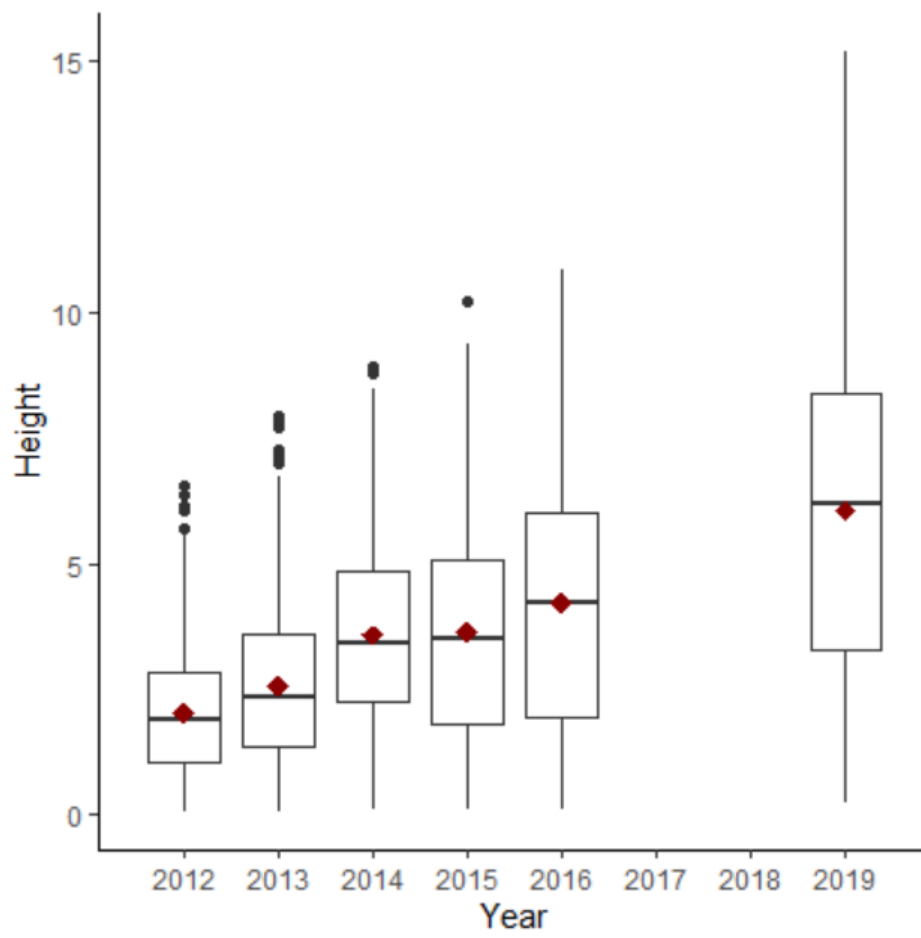


Figure S4. Boxplot showing the relationship between tree height and study year

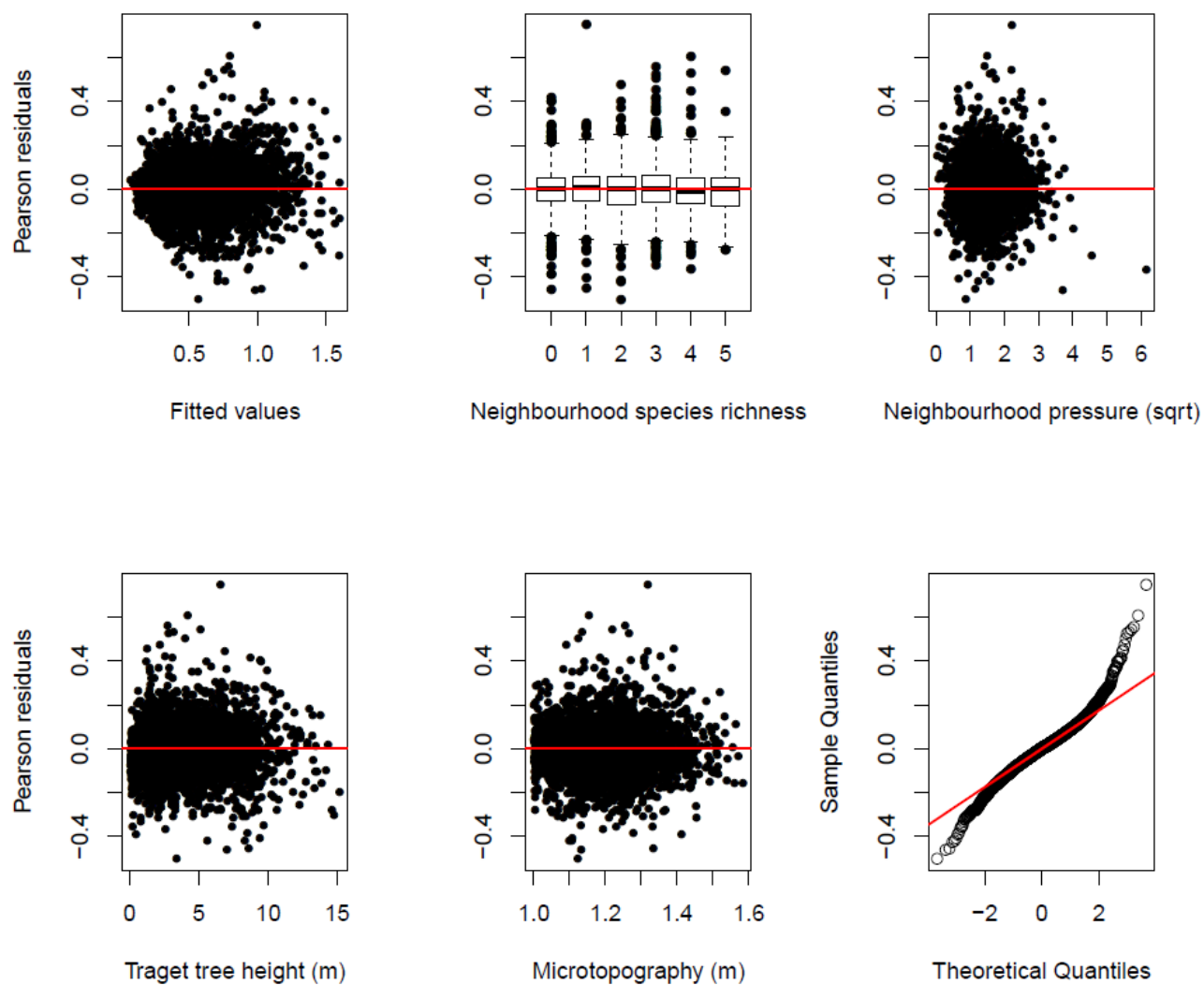


Figure S5. Residual plots of the best-fitting model