

The following appendix accompanies the article

Digital terrain modelling to investigate the effects of sea level rise on mangrove propagule establishment

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Appendix 1. Supplementary tables concerning the statistical analyses

Propagule counts

H₀: All propagules are equally distributed and have no preference for a specific site

First of all the effect of environmental conditions on propagule stranding suitability is tested by performing several One Way ANOVA (Tables A3 to A6) and MANOVA (Table A7) tests in which the independent variables (the factors) are represented by the different environmental settings (*i.e.* root complex, slope and substrate) and where the dependent variables (Table A2) contain the number of propagules counted within the several plots. An overview of the 11 different combinations of plots with the same characteristics are shown in Table A1. The results show that for all previous environmental variables the total number of counted propagules is significantly different (Table A6). The *post hoc* tests (Scheffé) for the variables ‘root complex’, ‘substrate’, ‘slope’ indicate that the significant variation is mainly caused respectively by the categories ‘no roots’, ‘sand’, ‘no slope’, since these groups have a p value < 0.05 in combination with their 2 remaining groups. The test also indicates that the difference between their 2

remaining groups is not significant (respectively $p = 0.927$, $p = 0.487$, $p = 0.847$). When also considering the descriptive statistics, it seems that in general the least suitable features for stranding or self planting of propagules are ‘no roots’, ‘sand’, ‘no slope’, but additional information is derived from the interactions between the independent factors by means of several MANOVA / Univariate tests.

The univariate analysis¹ combining ‘root complex * substrate’ and ‘slope * substrate’ both show a significant interaction effect between the combined factors (respectively $p = 0.000$; $p = 0.009$, Table A6). When analysing the descriptive statistics, we can conclude that the highest average values are assigned to the combinations ‘prop roots – clay’, ‘pencil / prop roots – silt’, ‘no slope – clay / silt’. Furthermore the interaction between ‘root complex * substrate’ and ‘slope * substrate’ in combination with the different species and positions shows p values < 0.05 for all test variables (Table A7) and the most favourable combinations derived from the descriptive statistics are the following: ‘prop roots – clay – *Ceriops tagal*’, ‘pencil roots – silt – *Rhizophora mucronata*’ and ‘gentle slope – clay – *C. tagal*’, ‘gentle slope – silt – *R. mucronata*’, ‘clay – prop roots – stranded’ and ‘silt – pencil roots – stranded’. Therefore we can conclude that propagules are not all distributed equally, but that they have a preference for sites with certain features.

H₀: There is no difference between the 2 Rhizophoraceae species regarding suitability of the environment of establishment

When combining each environmental condition with the factors ‘species’ we can conclude that these MANOVA tests (Table A7) show significant results for the factors ‘root complex’ and ‘substrate’ (p values < 0.05), but there are no interactions between the factors ‘slope’ and ‘species’ for the test variables ‘H’ (stranded propagules, horizontal), ‘V’ (self-planted propagules, vertical), ‘Tot’ (both stranded and self-planted propagules) (respectively $p = 0.333$, $p = 0.249$, $p = 0.239$). *Ceriops tagal* and *Rhizophora mucronata* respectively have a clear preference for ‘prop roots’ / ‘clay’ and ‘pencil roots’ / ‘silt’.

H₀: Propagules establish equally through stranding and self-planting

In view of the interactions with the factor ‘position’ (Table A7), we were able to conclude that for the combination with the factor ‘root complex’ and ‘substrate’ all test variables (total number of propagules of *Rhizophora mucronata*, ‘R’; total number of propagules of *Ceriops tagal*, ‘C’; total number of propagules, ‘Tot’) showed a significant p value, whereas the combination with the factor ‘slope’ showed no significant p value for the test variable ‘C’ ($p = 0.079$). In each category of the factors ‘root complex’ and ‘substrate’ we encounter on average more stranded propagules than self-planted. Furthermore when we look at the stranded and the self-planted propagules separately, we can first of all conclude that the average number of stranded propagules is highest in the category ‘pencil roots’ (with exception of the test variable ‘C’) and that self-planted propagules were mainly counted within plots dominated by ‘prop roots’ (with exception of the test variable ‘C’). Secondly, we can assume that the category ‘silt’ and ‘clay’ on an average count more stranded propagules for respectively the testvariable ‘R’ and ‘C’ and when considering the self-planted propagules, this is true for the test variables ‘C’ and ‘Tot’ in the category ‘clay’. Additionally, the interactions between ‘slope’ * ‘position’ give the highest averages for the combination stranded propagules on a flat surface.

¹ These tests do not include the different combinations between ‘root complex’ and ‘slope’ because the plots with pencil roots and prop roots could only be set up in areas with a flat topography.

Table A1. Overview of the 11 different combinations of plots with the same characteristics

Root complex	Substrate	Slope		
		gentle	medium	strong
Prop roots	Sand	PSG		
	Loam	PLG		
	Clay	PCG		
Pencil roots	Sand			
	Loam	PLG		
	Clay			
No roots	Sand	NSG	NSM	NSS
	Loam	NLG		
	Clay	NCG		NCS
Sea grass	Sand	SeaSG		
	Loam			
	Clay			

Table A2. Overview of the different categories representing the dependent variables within the 1-way ANOVA / MANOVA tests

Category	Acronyms
Propagules of <i>Cerriops tagal</i> in a horizontal position / stranded	Ct H
Propagules of <i>Cerriops tagal</i> in a vertical position / self planted	Ct V
Propagules of <i>Rhizophora mucronata</i> in a horizontal position / stranded	R H
Propagules of <i>Rhizophora mucronata</i> in a vertical position / stranded	R V
Total number of propagules in a horizontal position / stranded	Tot H
Total number of propagules in a vertical position / self planted	Tot V
Total number of propagules of <i>Cerriops tagal</i>	Tot C
Total number of propagules of <i>Rhizophora mucronata</i>	Tot R
Total number of propagules of <i>Cerriops tagal</i> and <i>Rhizophora mucronata</i> , <i>V</i> and <i>H</i>	Tot

Table A3. Overview of the results of the 1-way ANOVA tests where the independent variables and the factor are respectively represented by the different categories (Ct H, Ct V, etc.) and the different combinations of plots (PCG, PSG, etc.). Acronyms are explained in Tables A1 & A2.

<i>One way ANOVA</i>																		
<i>Factor: combination of plots</i>																		
	Ct H		Ct V		R H		R V		Tot H		Tot V		Tot C		Tot R		Tot	
	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>	<i>F</i>	<i>p</i>
PCG	217.01	0.000	53.478	0.000	17.000	0.000	0.000	1.000	38.748	0.000	217.01	0.000	92.794	0.000	17.000	0.000	78.406	0.000
PSG	0.000	1.000	0.000	1.000	1.059	0.363	8.000	0.002	1.059	0.363	8.000	0.002	0.000	1.000	1.787	0.189	1.787	0.189
PLG	74.284	0.000	10.000	0.000	1.952	0.121	6.182	0.001	24.744	0.000	9.538	0.000	53.968	0.000	1.582	0.198	18.598	0.000
NSM	1.923	0.146	0.000	1.000	4.267	0.120	0.000	1.000	1.185	0.331	0.000	1.000	1.923	0.146	4.267	0.120	1.185	0.331
NSG	2.714	0.870	0.000	1.000	6.400	0.060	0.000	1.000	0.316	0.732	0.000	1.000	2.714	0.087	6.400	0.060	0.316	0.732
NSS	4.000	0.063	0.000	1.000	4.000	0.063	0.000	1.000	0.000	1.000	0.000	1.000	4.000	0.063	4.000	0.063	0.002	1.000
NCG	3.599	0.024	1.000	0.405	30.250	0.000	0.000	1.000	16.188	0.000	1.000	0.405	3.780	0.200	30.250	0.000	16.330	0.000
PLG	0.000	1.000	0.000	1.000	2.548	0.130	4.000	0.063	2.548	0.130	4.000	0.063	0.000	1.000	1.048	0.321	1.048	0.321
SeaSG	0.003	1.000	0.000	1.000	0.500	0.613	0.000	1.000	0.500	0.613	0.001	1.000	0.001	1.000	0.500	0.613	0.500	0.613
NLG	1.083	0.354	4.000	0.320	1.846	0.180	0.001	1.000	3.583	0.043	4.000	0.320	0.89	0.915	1.846	0.180	1.156	0.332
NCS	0.000	1.000	0.003	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.004	1.000	0.000	1.000	0.000	1.000

Table A4. Overview of the results of the 1-way ANOVA tests where the independent variables and the factor are respectively represented by the different categories H, V, Tot and ‘Species’. Acronyms are explained in Tables A1 & A2

<i>One way ANOVA</i>						
<i>Factor: Species</i>						
	Tot H		Tot V		Tot	
	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p
PCG	137.923	0.000	276.571	0.000	171.836	0.000
PSG	84.500	0.000	8.000	0.012	60.000	0.000
PLG	2.473	0.135	0.643	0.434	1.616	0.222
NSM	10.894	0.005	0.000	1.000	10.894	0.005
NSG	1.085	0.313	0.000	1.000	1.085	0.313
NSS	0.800	0.384	0.000	1.000	0.800	0.384
NCG	5.658	0.030	1.000	0.332	5.789	0.029
PLG	38.337	0.000	4.000	0.063	34.116	0.000
SeaSG	3.368	0.085	0.000	1.000	3.368	0.085
NLG	17.021	0.010	16.000	0.010	24.807	0.000
NCS	2.286	0.150	0.000	1.000	2.286	0.150

Table A5. Overview of the results of the 1-way ANOVA tests where the independent variables and the factor are respectively represented by the different categories R,C, Tot and 'Position'. Acronyms are explained in Tables A1 & A2

<i>One way ANOVA</i>						
<i>Factor: Position</i>						
	R		C		Tot	
	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p
PCG	32.667	0.000	69.681	0.000	71.396	0.000
PSG	48.400	0.000	0.000	1.000	48.400	0.000
PLG	74.941	0.000	99.000	0.000	237.053	0.000
NSM	8.258	0.011	36.571	0.000	45.011	0.000
NSG	6.400	0.022	5.224	0.036	6.400	0.022
NSS	4.000	0.063	4.000	0.063	8.000	0.063
NCG	30.250	0.000	22.891	0.000	58.500	0.000
PLG	74.941	0.000	99.000	1.000	237.053	0.000
SeaSG	2.286	0.150	0.000	1.000	2.286	0.150
NLG	5.333	0.035	19.512	0.000	34.228	0.000
NCS	2.286	0.150	0.000	1.000	2.286	0.150

Table A6. Overview of the results of the 1-way ANOVA and the 'Univariate' tests where independent variable and (combination of) the factors are respectively represented by the total number of propagules counted within each plot 'Tot' and the different environmental conditions 'Root complex', 'Substrate', 'Slope', 'Root complex * Substrate', 'Substrate * Slope'

<i>One way ANOVA</i>							<i>Univariate tests</i>			
Test variable 'Tot'	Factor						Combination of factors			
	Slope		Root complex		Substrate		Root complex * Substrate		Substrate * Slope	
	p	<i>F</i>	p	<i>F</i>	p	<i>F</i>	<i>F</i>	p	<i>F</i>	
	34.118	0.000	13.556	0.000	9.748	0.000	20.802	0.000	6.887	0.009

Table A7. Overview of the results of the MANOVA tests where the independent variables and the combination of factors are respectively represented by ‘Tot’, ‘H’, V, etc and the different environmental conditions ‘Root complex * Species’, ‘Root complex * Position’, etc. Acronyms are explained in Table 2

<i>MANOVA</i>										
Combination of factors										
Test variable	Slope * Species		Root complex * Species		Substrate* species		Slope * Substrate * Species		Root complex * Substrate * Species	
	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p
Tot	0.686	0.504	14.579	0.000	12.805	0.000	10.056	0.002	35.672	0.000
Tot H	0.501	0.606	7.632	0.005	23.620	0.000	11.040	0.001	39.751	0.000
Tot V	1.392	0.249	6.529	0.023	11.112	0.000	4.738	0.030	15.552	0.000
Test variable	Slope * Position		Root complex * Position		Substrate* Position		Slope * Substrate * Position		Root complex * Substrate * Position	
	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p	<i>F</i>	p
Tot	5.678	0.004	26.238	0.000	8.504	0.000	2.687	0.102	5.544	0.004
Tot R	10.698	0.000	58.694	0.000	27.587	0.000	0.188	0.665	11.548	0.000
Tot C	2.550	0.079	4.258	0.015	5.276	0.005	4.023	0.045	11.499	0.000