Extended Data for ´*Roots of cooperation: can root graft networks benefit trees under stress?*´

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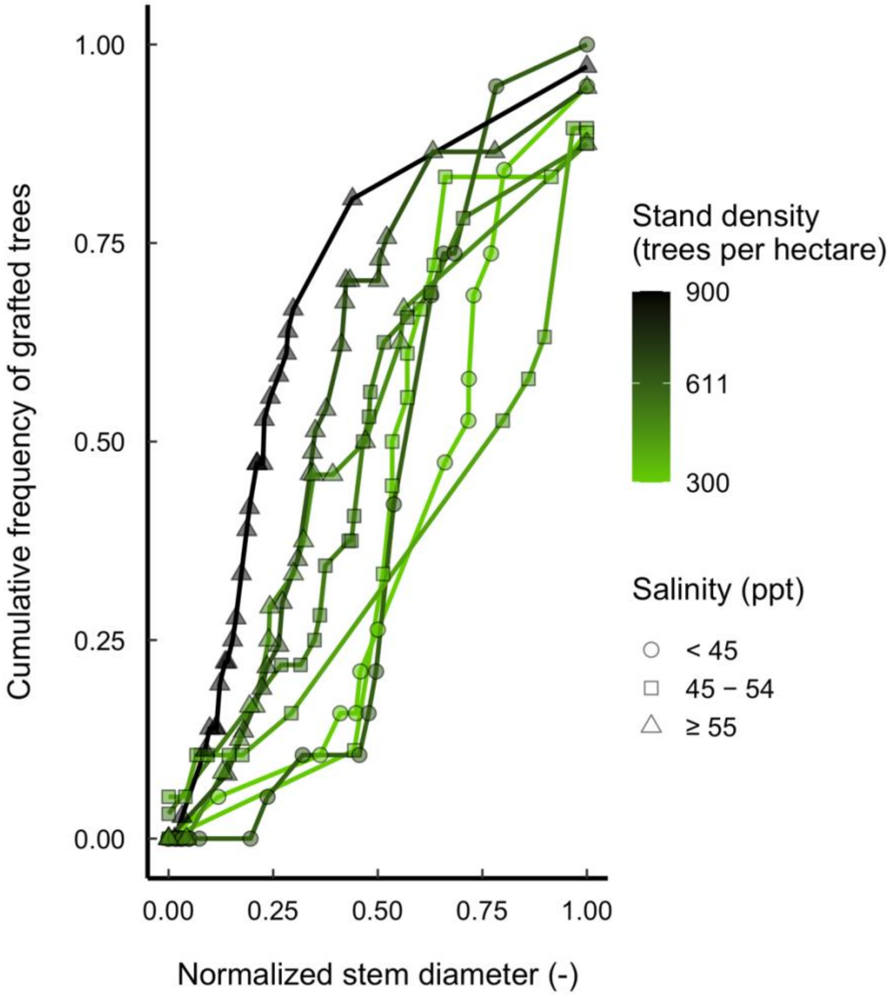
Content

Logistic regression

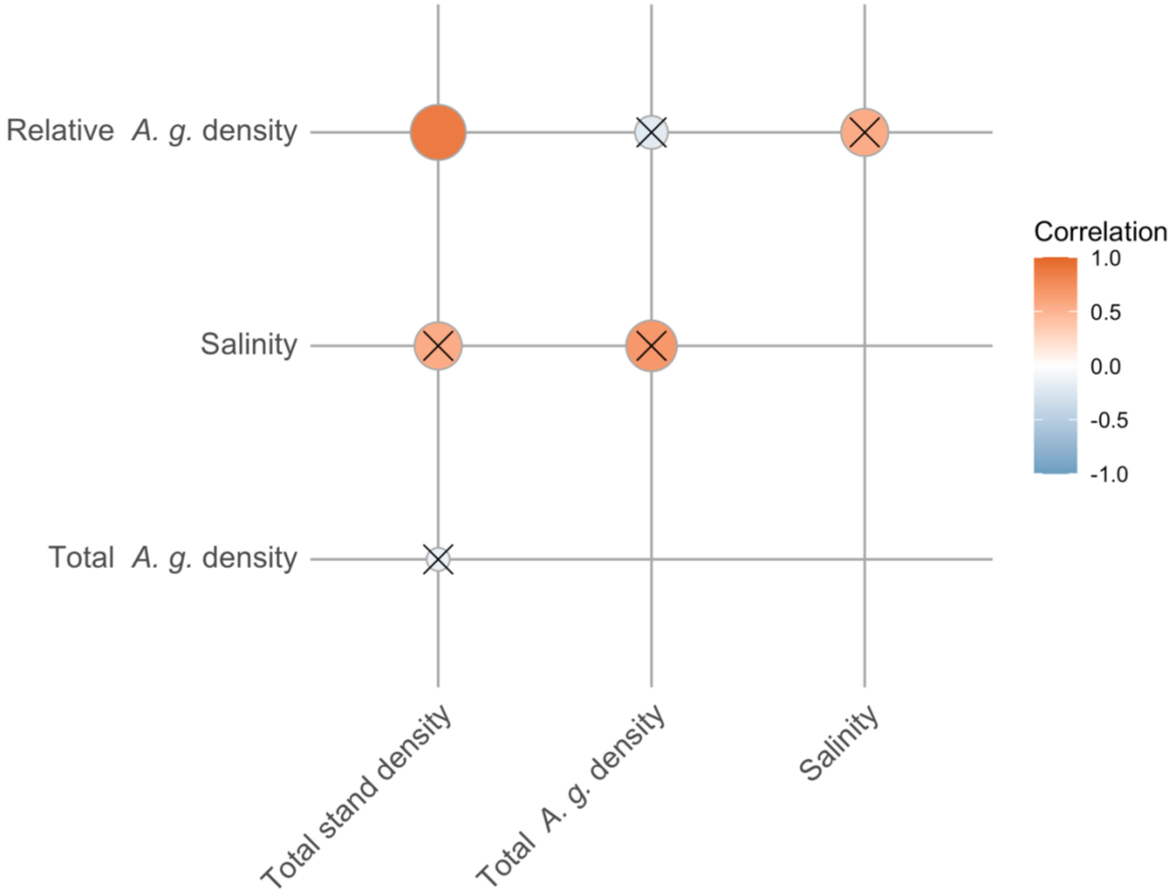
Extended Data Table 1. Logistic regression of predictors of root grafting. Odds ratios and their 95% confidence intervals (CI) for z-transformed predictors of root grafting. Odds ratios >1 indicate a positive effect of the predictor variable on the response, while values <1 indicate a negative effect. The estimated coefficients of the odds ratios are significant if the CI range does not pass through 1. The highest correlation was found between stem diameter and high-stress level, while a marginal negative effect was observed for the interaction term between stem diameter and stress level.

Grafting	Odds ratio	CI 2.5–7.5
Intercept	1.28	0.96–1.73
Stem diameter	2.73	2.04–3.73
Total density (trees ha−1)	0.76	0.57–1.05
Salinity (ppt)	0.93	0.70–1.26
Total density (trees ha−1):salinity (ppt)	1.09	0.81–1.52
Stem diameter: total density (trees ha−1)	0.68	0.50–0.90
Stem diameter (trees ha−1):salinity (ppt)	0.56	0.41–0.75
Salinity:total density (−1 SD)+	1.12	0.78–1.65
Salinity:total density (+1 SD)+	0.52	0.33–0.80

Note: Effect of predictor on grafting probabilities. $^{+}$Odds ratios for cross-level interactions were obtained by creating a model to specifically estimate the CI for the biggest trees in the stand (+1 standard deviation [SD]) and the smallest trees (−1 SD) based on stem diameter. The estimates show a reduced probability of grafting for the biggest trees in the stands with increasing salinity and stand density.



Extended Data Figure 1. Probability of grafting for the eight forest stands with increasing density and sediment salinity using z-transformed values for stem diameter in the model. The steepest grafting probability is for the site that had the highest salinity and the highest stand density.

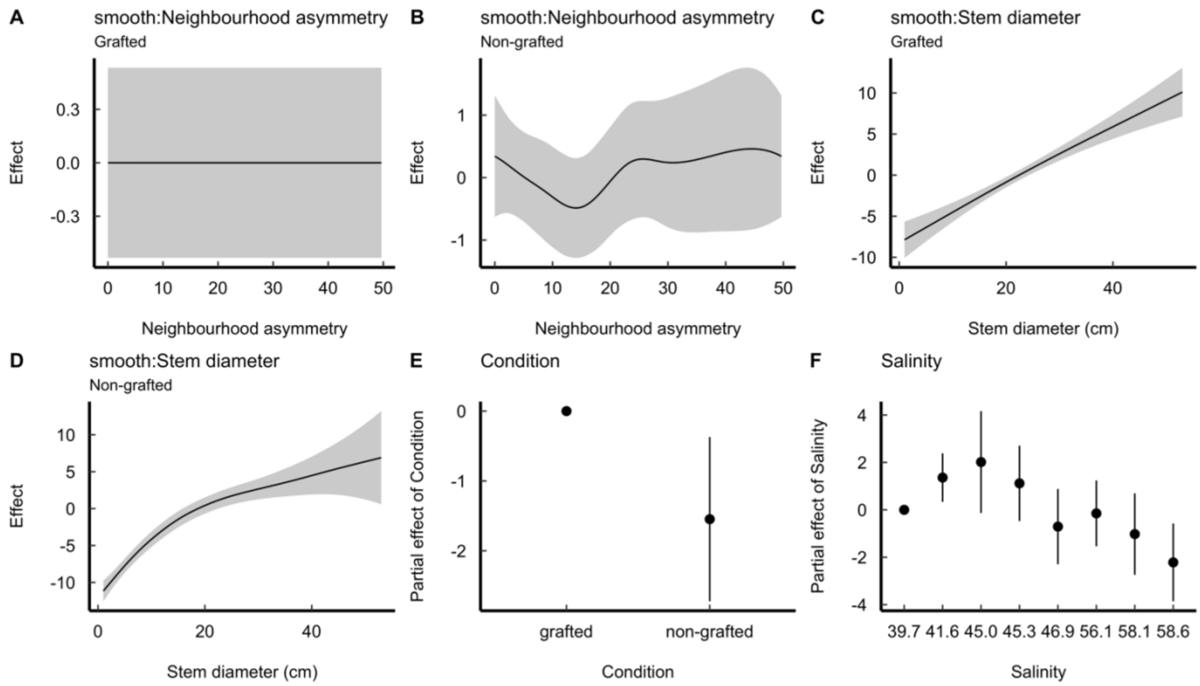


Extended Data Figure 2. Pearson correlation of the level 2 variables in the logistic regression. X indicates non-significant correlations between variables. Relative A. g. density is the percentage of *A. germinans* relative to all trees (no. of *A. germinans* trees/no. total trees * 100), and Total A. g. density is the count of *A. germinans* trees per plot.

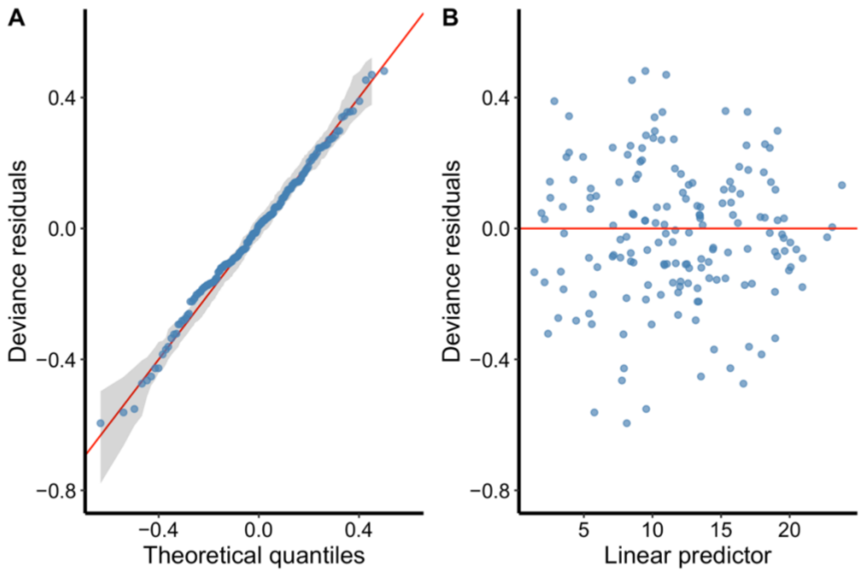
Generalised additive mixed effects model

A generalised additive mixed effects model was implemented to understand the effects of asymmetric neighbourhoods and grafting on tree height. The best model for explaining tree height (selected using a minimal Akaike information criterion value following a stepwise removal of non-significant response variables) included asymmetric neighbourhood, salinity, stem diameter and condition as fixed effects, with asymmetric neighbourhood and stem diameter as smooth terms with smooth functions (cyclic cubic regression spline and Duchon spline for asymmetric neighbourhood and stem diameter respectively) and the sampling plot as a random effect.

The final model showed that neighbourhood asymmetry for grafting does not have a significant effect on tree height ($p = 0.48$; Extended Data Fig. S3 A), while for non-grafted trees, the size of the neighbourhood asymmetry had an increasingly negative effect on height up to the asymmetric neighbourhood size of 18 (Extended Data Fig. 3B). This negative effect was reduced at asymmetric neighbourhoods >20, which could be explained by reduced observations for such asymmetric neighbourhoods (Extended Data Fig. 3B). The stem diameter–height relationship followed different trendlines: the height increment for grafted trees had a close to linear relationship with stem diameter growth ($p < 0.0001$; Extended Data Fig. S3C), while the rate of height increment for non-grafted trees was slower for stem diameters between 10 and 30 cm ($p < 0.001$; Extended Data Fig. 3D), suggesting different allometric relationships for grafted and non-grafted trees. However, overall, the heights of non-grafted trees were lower than those of grafted trees ($p = 0.03$), and this effect was particularly significant for non-grafted trees at increasing asymmetric neighbourhood sizes ($p < 0.01$). Additionally, a major factor limiting tree growth was salinity, which had a significant effect on tree height for all sites, with a mean salinity >46.8 ppt (with $p < 0.001$ for all cases; Extended Data Figure 3. E), while a partial effect was positive for sites with salinity values <45.5 ppt.



Extended Data Figure 3. Effects on height of smooth terms. Asymmetric neighbourhood and stem diameter for grafted trees (**A** and **C**, respectively) and non-grafted trees (**B** and **D**, respectively) and partial effect of grafting condition (**E**) and salinity (**F**) on tree height derived from the generalised additive mixed effects model. The black internal tick lines along the x-axes denote observation points. The shaded ribbons for panes **A**–**D** and the vertical lines in panes E and F express 95% confidence intervals. The final model had a strong coefficient of regression (R2 = 0.78), which explained 84.9% of the deviance with no detection of overdispersion (Extended Data Fig. 4).



Extended Data Figure 4. Distribution of modelled deviance residuals vs. theoretical quantiles with 95% confidence intervals (**A**) and deviance residual dispersion (**B**) of the selected generalised additive mixed effects model to describe the effect of neighbours, environmental variables and grafting condition on tree height.