Tropical tree diversity enhances light capture through crown plasticity and spatial and temporal niche differences

Jurgis Sapijanskas, Alain Paquette, Catherine Potvin, Norbert Kunert and Michel Loreau

Appendix D: Supplementary methods and results for the stratified bootstrap tests.

We designed a set of stratified bootstrap tests to detect diversity effects on light capture with our mechanistic light interception model. All tests share the same basic ingredients: tree assemblages are generated under a specific null hypothesis, percent light (GLI) transmitted through these virtual assemblages is computed with the calibrated light model and compared to both direct GLI observations and that predicted by the model under the observed tree stands. The double comparison allowed us to check whether model bias contributed to the results.

First, we tested whether mixtures captured more light than their constituent monoculture that reduced light most (Fig. 1A in the main text). Mortality and the size of trees in the direct vicinity of the measurement point are the main factors influencing light availability and generate spatial effects of biotic and abiotic origins that can be independent of diversity (e.g. most mortality events occurred within the first few months following establishment and were unrelated to the diversity treatments). We computed null expectations for GLI in mixtures based on monoculture performance through stratified bootstrapping to control for these spatial effects and isolate diversity effects. For each species and each diversity treatment, we divided the distribution of individual tree basal area in Q quantiles. For each species i, null assemblages were created by replacing all live tree in mixtures where that species was present with a tree sampled from species i's monoculture and belonging to the same basal area quantile as observed in the mixture. We therefore conserved the spatial distribution of trees including their relative performance in the focal diversity level. Created from trees sampled in monocultures, the null assemblages differed from the observed mixture subplot in average tree size and crown architecture if overyielding, underyielding or plastic changes in crown shape occurred in the mixtures. GLI was computed with the light model for 5000 replicate simulations to obtain a bootstrap GLI distribution for every mixture subplot that included species i. In total, we thus computed as many GLI distributions as the number of mixture subplots times their species richness. For each mixture subplot, its observed GLI value was then compared separately with each GLI distribution obtained from its constituent species. Systematically smaller GLI values in observed mixtures compared to expectations based on all their constituent monocultures, and thus on the best performing monoculture, are interpreted as evidence that light interception was enhanced thanks to differences in architecture among species, overyielding and/or plastic changes in crown geometry.

Second, we tested for an effect of plastic changes in crown shape. This test did not require stratified bootstrapping to control for spatial effects since it uses tree size as observed in the field. It is fully described in the main text.

Third, we repeated the same test as the first one except that the effects of overyielding and plastic changes in crown shape were removed. For each species i, null monoculture assemblages were created by sampling trees of species i from plots with the same species richness as the focal mixture subplot and and belonging to the same basal area quantile as observed in the focal subplot. Trees were drawn from polycultures instead of monocultures so that systematic higher GLI values in observed polycultures would indicate that differences in architecture among species alone allowed polycultures to outperform their ‘best’ constituent monoculture.

Supplementary results

Results for the first two texts can be found in the main text. The second test carried out when removing the effects of overyielding and plastic changes in crown shape showed that no mixture captured more light than expected for the best monoculture that would have grown as fast as the mixture (Fig. D1). Although significant (main text), the effects of differences in architecture among species were thus not strong enough to explain why mixtures outperformed the best monoculture.

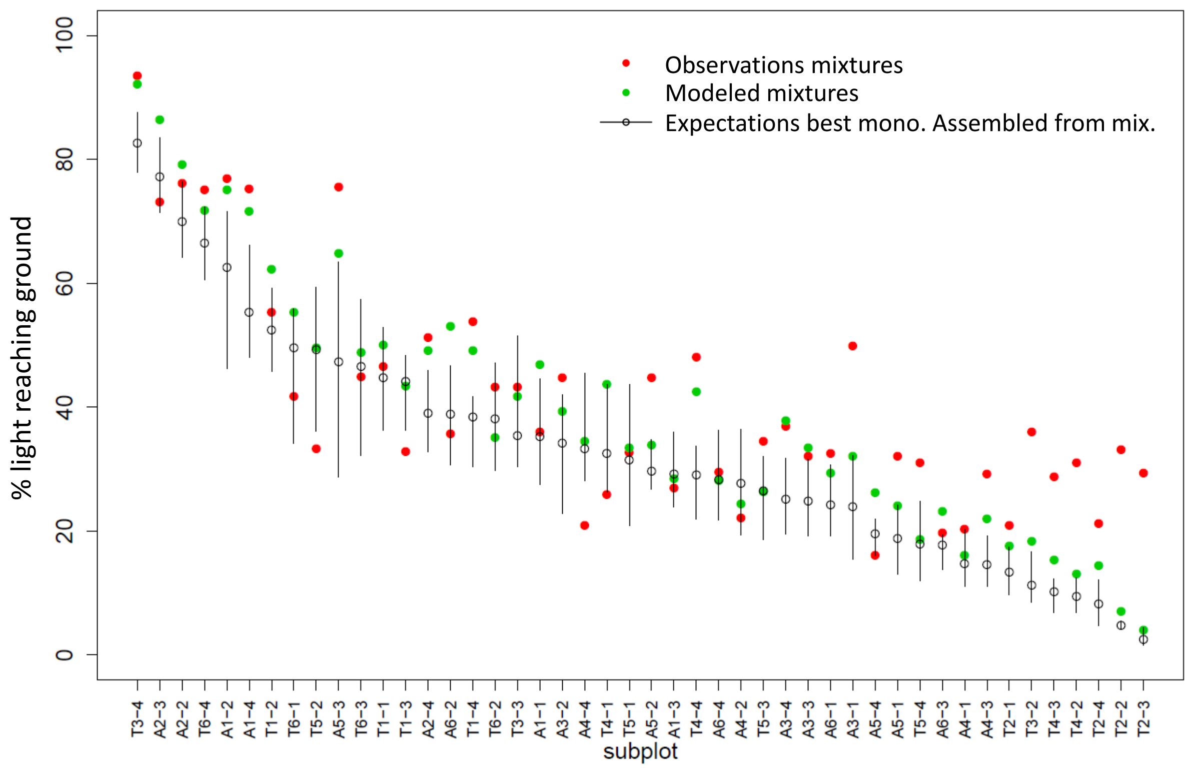

Fig. D1. Diversity effects on light capture when all species are fully foliated due to architectural differences among species only. Green symbols : light reaching ground as predicted by the light model. Red symbols: observations in mixtures. Open symbols and lines: mean and confidence intervals of light capture by the best constituent monoculture that would have grown as fast as observed for that species in mixtures. Lines are 99% CI to obtain a 5% type I error at the multiple-comparison-level (Bonferroni correction).