Functional diversity increases aboveground biomass via increasing tree crown complementarity in tropical forests of Hainan Island, Southern China

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Abstract

The niche complementarity and mass ratio or selection hypotheses are well-accepted and widely applied in contemporary ecology. Yet, few studies have provided a multivariate test for the tree crown complementarity mechanism in natural tropical forests. Here, we hypothesized that crown complementarity is a potential ecological mechanism for linking positive functional diversity and aboveground biomass while considering for the positive direct and indirect effects of climatic water availability and soil fertility in natural tropical forests. To test this hypothesis, we used structural equation models on biophysical data from 187,748 trees across 712 plots in tropical forests in Hainan Island of Southern China. The results showed that aboveground biomass increased directly with increasing functional diversity ($\beta = 0.24$, $P < 0.001$), individual tree crown variation ($\beta = 0.18$, $P < 0.001$) and climatic water availability ($\beta = 0.17$, $P < 0.001$). As such, functional diversity enhanced individual tree crown variation ($\beta = 0.26$, $P < 0.001$) and hence increased aboveground biomass indirectly via individual tree crown variation ($\beta = 0.05$, $P < 0.001$). Additional positive effects of climatic water availability and soil fertility on aboveground biomass were accounted indirectly via increasing individual tree crown variation and/ or functional diversity. This study shows that individual tree crown variation is a potential ecological mechanism for the positive effect of functional diversity on aboveground biomass, and as a mechanism for species coexistence through maintenance of functional diversity in natural forests. This study suggests that a multilayered stand structure, having a species mixture of both shade tolerant and intolerant with contrasting functional strategies, can increase species coexistence and aboveground biomass in natural forests. We, therefore, suggest that proper silvicultural operations would be helpful to further improve the light partitioning for biodiversity conservation and high forest functioning in the studied forests, and other natural forests in general.

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