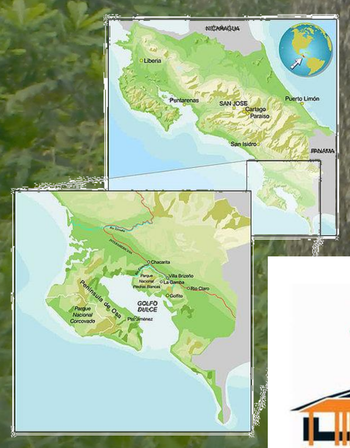

Assessment of allometric relationships of tropical trees in Costa Rica

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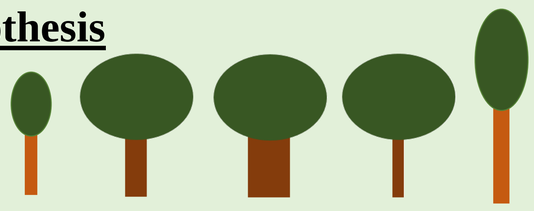
Background

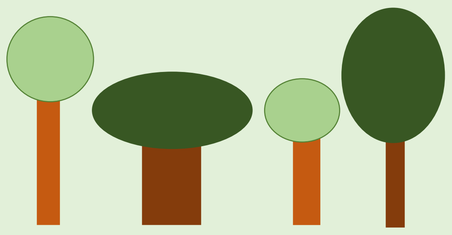
Growth of trees, and their biomass accumulation, is an essential part of ecological studies due to its link with global carbon stocks (Ketterings et al. 2001). However, forest biomass estimates routinely utilize only diameter measurements (Feldpausch et al. 2012) or a constant height-diameter relationship (Feldpausch et al. 2010), and therefore could be imprecise on what the actual growth ratio is for the selected forest area. A more concise model formed from utilizing additional measurements of structural variables such as total tree height, crown height, and crown width would greatly reduce error in allometric equations (Goodman et al. 2014). By understanding specific species' allometry, and the factors that dictate growth habits, this could help improve our understanding of more accurate biomass data along with understanding differentiation of regional environmental effects on growth and forest ecology.

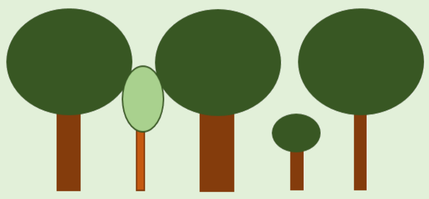
Methodology

In March and April, 2018, approximately 4,940 native individual trees consisting of over 100 species where measured for diameter at breast height (D), total tree height (H), crown base height, crown width, and relative position within the reforestation area of Finca Amable, Costa Rica using manual measurements paired with laser equipment.. The height/diameter relationship per species was described as $H = a*D^b$. To compare species-wise H/D relationship with other characteristics, we related to parameter „a" of this relationship to to species´ successional class, wood density, and the effect of neighboring tree effects. The successional status was was based on the species' occurrence in either old-growth or second-growth forests from existing literature and ranged from 0 for pioneers to 1 for old-growth specialists. These data were used to test the following hypotheses:

Hypothesis







1. Tropical tree species differ in their allometric relationships

2. A. Pioneer trees (light green), which tend to be shade-intolerant, invest relatively more in height growth compared to old-growth specialist (dark green)
   B. On the other hand, trees with high wood density, which tend to be shade-tolerant species from old-growth forest, should be able to support a crown with a relatively thinner stem (high H/D).

3. Pioneer trees respond to shading with increased height growth (high H/D) compared to old-growth specialists

Results and Discussion

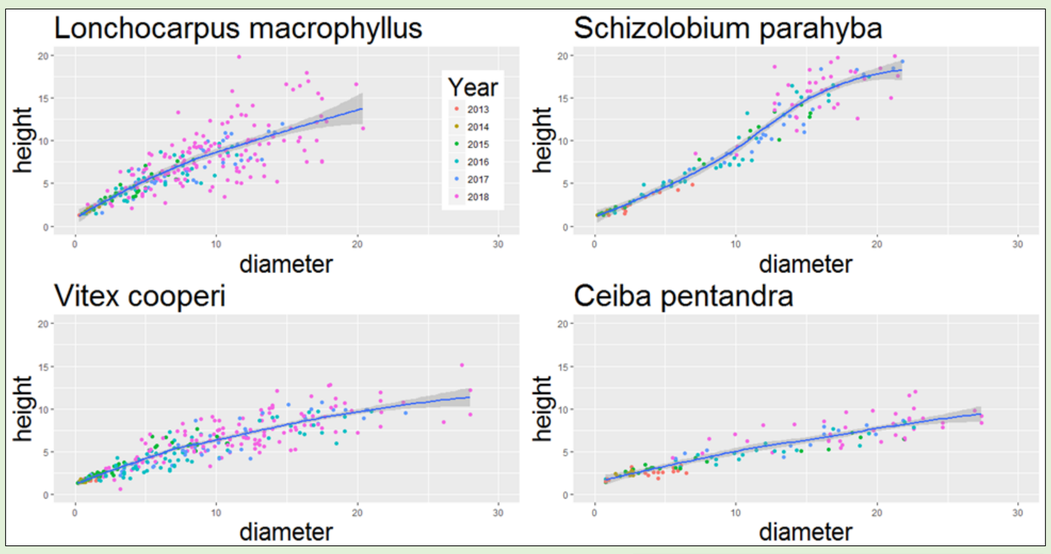


Figure 1: Height/diameter relationships of four species

	df	Pr(>F)
DBH	1	<2e-16 ***
species	45	<2e-16 ***
DBH:spec.	45	<2e-16 ***

Species differed significantly in their H/D ratio (Fig. 1, significant DBH:spec interaction in the ANOVA)

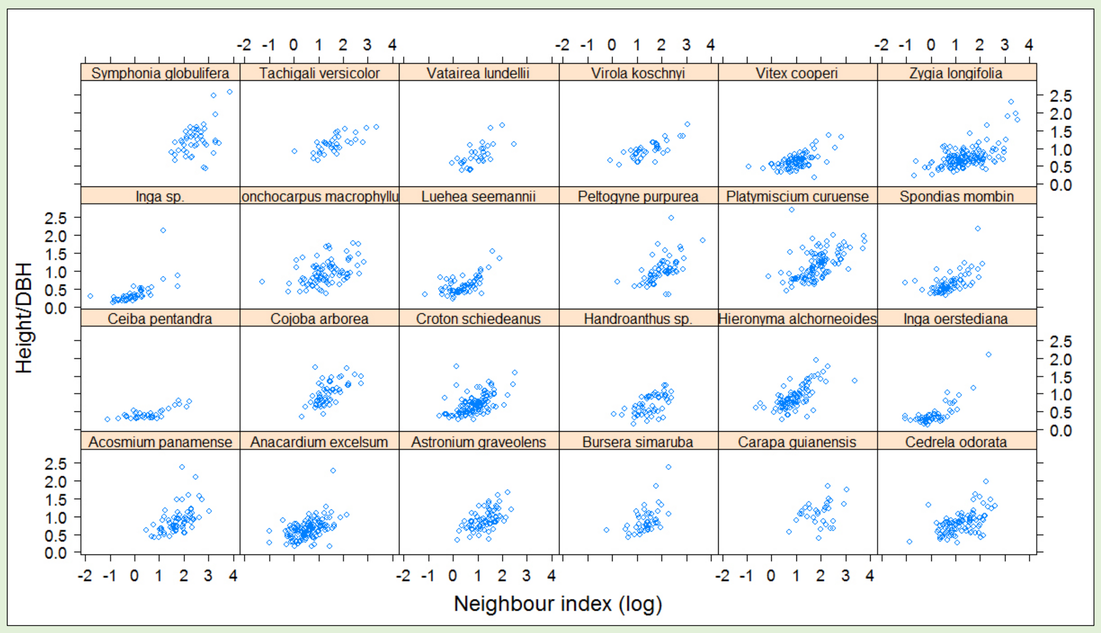


Figure 4: Neighboring effects on H/D relationship

$$NIi = \sum_{j=1}^{n} \frac{\left(\frac{dbhj}{Dij}\right)}{dbhi}$$

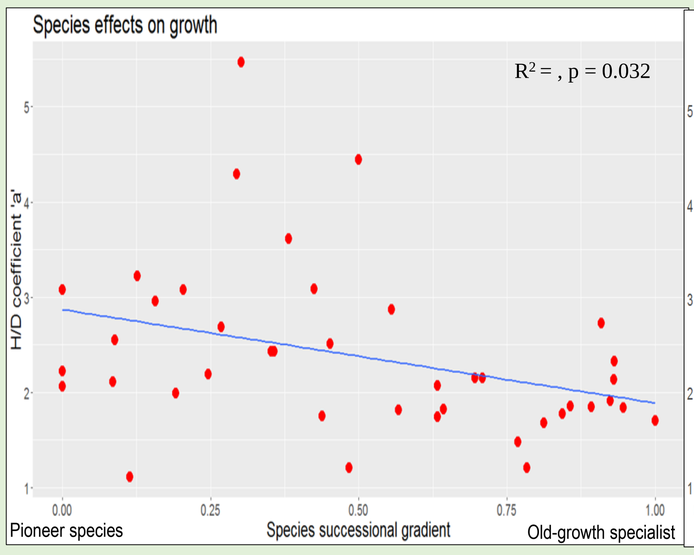


Figure 2: Species successional class in relation to H/D coefficient a

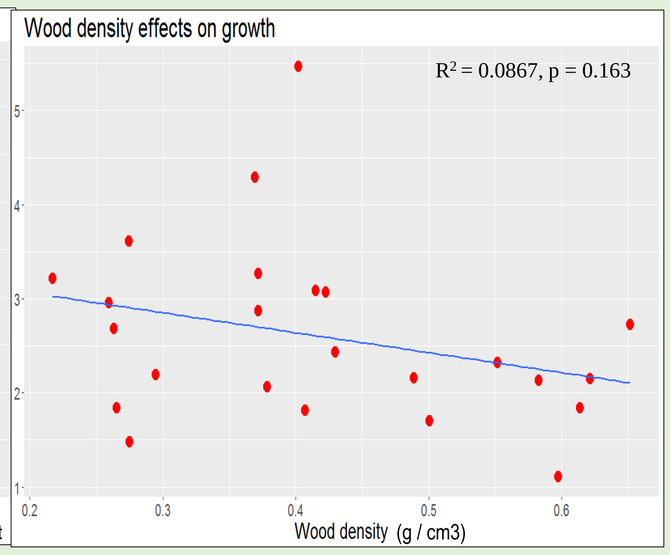


Figure 3: Wood density in relation to H/D coefficient a

Pioneer trees had significantly higher H/D compared to old-growth species (Fig. 2). However, wood density showed no significant effect and trees with high WD tended to have lower (contrasting to H2B) H/D (Fig. 3).

Neigboring effects were calculated as a neighbor index (NI) which included the distance to neighboring tree (D_{ij}), size of neighbor (dbh_j), and target tree (dbh_i). In nearly all species did the H/D increase with neighbor effects, suggesting that trees tend to invest more in height growth under shade (Fig. 4).

In conclusion, allometric relationships can vary according to genetic factors as well as environmental factors. Determining growth coefficients for this selected group of tropical trees helps to identify growth strategies in a localized environment. Which factors play a stronger role is yet to be determined by this study.

Acknowledgments

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