Predictors of tree growth in damar agroforests

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Introduction

Damar agroforest (Lampung, Sumatra) are multi-species, multi-strata plantations made up of a mosaic of individually owned - individually managed plots (Michon and de Foresta 1995). Damar (*Shorea javanica*), the main species is tapped for its resin and usually accounts for more than 60% of the total basal area. Many other tree species are also found including fruit trees, legume trees and timber trees. They are either actively tended or just tolerated to regrow from the natural regeneration. Little is known on the functional ecology and optimal management of such complex agroforests. We give here a first account of long-term measurements that were carried out from 1993 to 1998.

Material and methods: model description

Three one-hectare plots have been monitored for 4 to 6 years. Yearly girth measurements were made using a flexible meter tape. Only trees more than 5 cm of DBH (Diameter at Breast Height) were measured. At time of first measurement trees' location, crown position and crown form were recorded.

Because most species had very few representatives, they were grouped into 6 subsets for growth analysis (table 1).

Two types of crown indices were used: the Crown Form index (CF) and the Crown Position index (CP). These indices were developed for natural forest and are here applied to an agroforest environment.

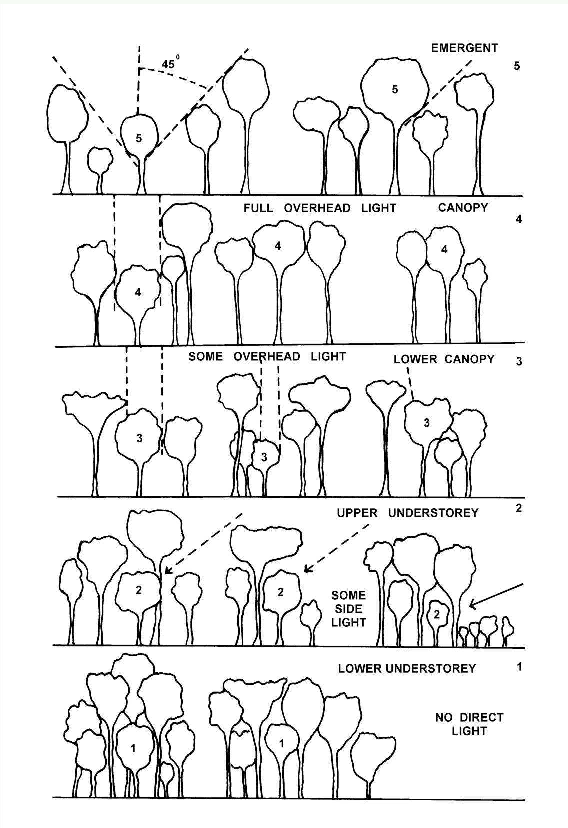

Figure 2: Dawkins crown position classification (in Alder and Synnot 1992).

Table 1: Species grouping used in analyzing growth data from three one-hectare plots of damar agroforest.

Group	Description
Damar	Composed of *Shorea javanica* the most common species in all plots and durian (*Durio zibethinus*). Durian is a common fruit tree of similar ecology that is also part of the upper canopy.
Duku	Composed of duku (*Lansium domesticum*) and ketupak (*Baccaurea dulcis*). The two fruit tree species have similar size and ecology, and both belong to the middle story.
Fast Growing Tall	Fast growing trees of tall stature such as *Alstonia angustifolia, Cinnamomum porrectum, Artocarpus elasticus, Pterospermum javanicum*, and various *Ficus* species.
Fast Growing Medium	Fast growing trees of medium stature such as : *Macaranga spp., Pithecellobium spp., Ficus sp, Erythrina sp.* and others
Treelets	Characteristic of sites of low management intensity, composed of small trees such as *Leea indica, Dendrocnide sp., Saurauia sp., Villebrunea rubescens...*
Miscellaneous	Comprises any species not in any of the above groups e.g. *Parkia speciosa, Arenga pinnata*

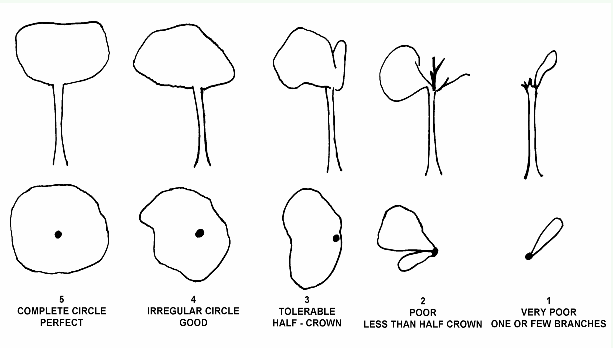

Figure 1: Dawkins crown form classification (in Alder and Synnot 1992).

The Crown Form index tries to capture the photosynthetic potential of a tree. It is an architectural characteristic and will tend to reflect the development history of the tree (figure 1).

The Crown Position index, which depends on the relative position of the crown within the canopy, reflects the light conditions (figure 2).

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Results

The average yearly increment was analyzed in a general linear model as a function of four predictors: Group as a categorical variable, and CF score, CP score and initial girth as numeric variables. The global adjusted r^2 ranged from 0.32 to 0.53 across sites. Contribution of each dependent variable to the reduction in total variance was assessed by comparing the complete model with a model lacking any one of the predictors (table 2). Most important contributions were those of factor Group and variable Crown Form. Crown position and initial girth only marginally contribute to the global r^2 except in site 2.

Groups were usually found to be significantly different from each other. Both CP and CF effects are usually highly significant (only exception: CP effect in site 3 not significant). Estimates of CF parameter appear to be more homogeneous than estimates of CP parameter across sites. Besides less consistent, (figure 3), CP parameter estimates are lower than CF parameter estimates (data not shown).

Initial girth parameter is always significantly different from 0 although its contribution to the reduction of the variance is small. It is consistently negative revealing a trend of slower growth of bigger trees.

Table 2: Comparison of the adjusted r^2 values of the general linear model relating average girth increment of individual trees to 4 predictors. Contribution of each predictor to the reduction in total discrepancy is estimated by comparing r^2 values for the complete model with a model lacking any one of the predictors.

Model / Site	complete model	model without Group	model without Crown Form	model without Crown Position	Model without Initial girth
1 (Gunung)	0.53	0.36	0.44	0.51	0.52
2 (Pahmung)	0.32	0.24	0.10	0.28	0.29
3 (Peneng)	0.35	0.15	0.27	0.35	0.34

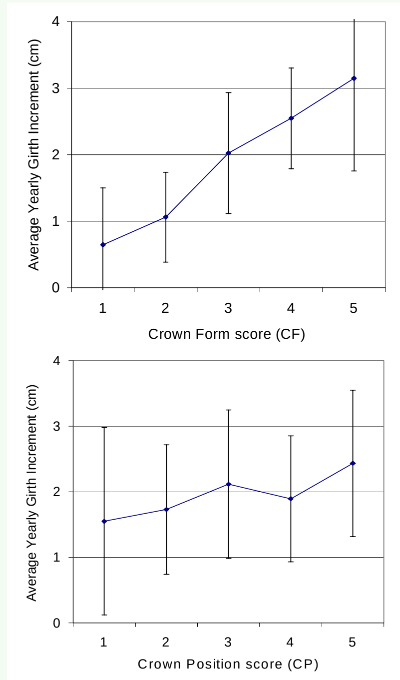

Figure 3a and 3b: Category plots showing average yearly girth increment of damar trees per crown score (3a crown form, 3b crown position). Vertical bars represent +/- standard deviation.

Discussion and conclusion

The complete model leaves about 40 to 60% of the variance unexplained. What are the possible sources of the residual variability?

Adding a competition index for below ground resources did not significantly increase the r^2, possibly due to spatial variation in fertility. The limited precision with which tree position is recorded in the field may also be partly responsible for the poor performance of the competition index which was shown to be sensitive to inaccurate positioning.

CP, although most often highly significant, only marginally contributes to reduction of variance. This was unexpected as it had been previously reported to be well correlated with growth in natural forests (Alder and Synnot 1992). Neither did we find interaction between CP and group, whereas it was expected that species of different ecology would react differently to light environment. These are hints suggesting that the CP score might not be reliable in the conditions of the damar agroforest. Recording CP every year instead of once and for all as it was done here would probably increase its predictive ability. Indeed abrupt changes may occur with canopy gap creations.

CF variable showed high correlation with yearly increment despite the fact that CF scoring is qualitative and subjective (figure 3). It seems that previous studies in natural forests could not show clear correlation between CF and yearly increment. According to our field experience, estimation of CF requires some knowledge of tree species ecology and architecture in order to be reliable. While these estimations are almost impossible to implement in case many species are unknown, like in a natural diverse rain-forest, high correlation between CF and yearly growth in our study indicates that this parameter is quite adapted to the conditions of an agroforest where a few well-known species dominate the forest composition.

Literature cited

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