Center for Environmental Systems Research

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Introduction

Orang Utan dispersing/predating seeds.

Timber harvest in tropical forests is a widely discussed topic for its impacts on deforestation and land conversion. As logging techniques and cycles vary, damages to the residual forest underly dramatic changes. Beside its function as global sink for carbon dioxide a logged-over forest following practises of reduced-impact logging is also expected to increase economic profit compared to a conventional logged forest. Other studies show convincingly that only economic profit will lead to conservation and sustainable practises. In this context, criteria for sustainability and ecological certification of timber wood are subject of much current debate. Computerised simulation models aiming to estimate growth and yield of tropical rain forest should become a useful tool to broaden this discussion.

In this study we use the rain forest growth model FORMIND2.0 for analysing the effect of various recruitment scenarios and different logging strategies on forest dynamics. Is there an optimal combination of the logging parameters (strategy, cycle length, recruitment assumptions) which maximise yields and minimise changes in the forest structure?

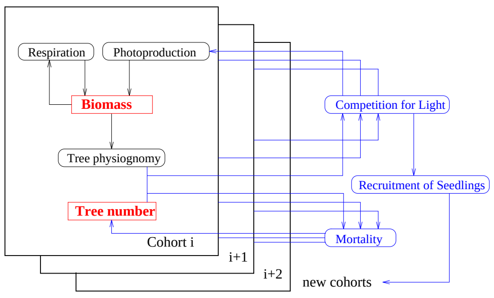
The model FORMIND

FORMIND2.0 is an individual-oriented process-based forest growth model to simulate the spatio-temporal dynamics of uneven-aged mixed forest stands. For complete model description of current version please refer to literature (Köhler and Huth, 1998; Kammesheidt *et al.* , 2000).

The model describes forest dynamics as a mosaic of interacting forest gaps of 20 $m^2 \times 20$ m^2 in size. Within these plots trees are not spatial-explicit distributed, and thus all compete for light and space following the gap model approach. The carbon balance of each individual tree incl. photosynthesis and respiration is modelled explicitly. Thus, we can match measured diameter increment for different PFT, size and light conditions accurately. Allometric relationships connect above-ground biomass, stem diameter, tree height and crown dimensions. Details of growth processes are taken from related model FORMIX3-Q (Ditzer *et al.* , 2000). Beside increasing mortality through self-tinning in dense plots one of the main processes of mortality is gap creation by falling of large trees. This process as well as seed dispersal from mature trees interlinks neighbouring plots with each other. Seed production rates of mature trees are effective rates regarding recruitment of seedling at a diameter threshold of 1 cm, where seed loss through predation is already incorporated.

Species grouping

We simulate forest dynamics for a dipterocarp lowland rain forest in Sabah, Malaysia.

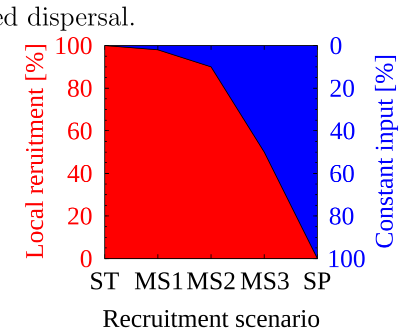


Interactions in FORMIND2.0. Main variables, processes within individuals, and interacting processes.

468 shrub and tree species of that area were assigned to 13 different plant functional types (PFT) based on their successional status (early, mid, late) and maximum height at maturity (shrubs, understorey, lower canopy, upper canopy, emergents). Species list available at http://www.usf.uni-kassel.de/usf/archiv/dokumente.en.htm. (Köhler *et al.* , 2000).

Recruitment scenarios

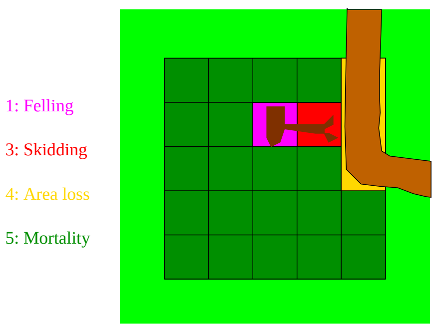
As former versions of the model were based on a recruitment scenario with constant input of seeds into a seed pool (**SP: seed pool**), independing on standing trees, we analyse the effect of those simplifications on model results. Alternatively input of new seeds into a seed pool depends on local mother trees of each PFT of a certain size (**ST: seed tree**). Three intermediate scenarios (**MS: mixed seeds**) are included in the analysis. Ecological meaning of ST might be a highly fragmented forest with recruitment depending on local production, whereas in SP simulation area might be embedded in a large intact forest area with unaltered seed dispersal.



Definition of recruitment scenarios.

Logging scenario

We distinguished reduced impact (**RIL**) and conventional logging (**CON**). Both differ in damages to residual stand as shown in figure and table. Only trees of mid and late successional species with a diameter d $\geq$ 60 cm are logged. Cycles length between 20 and 80 years were analysed.



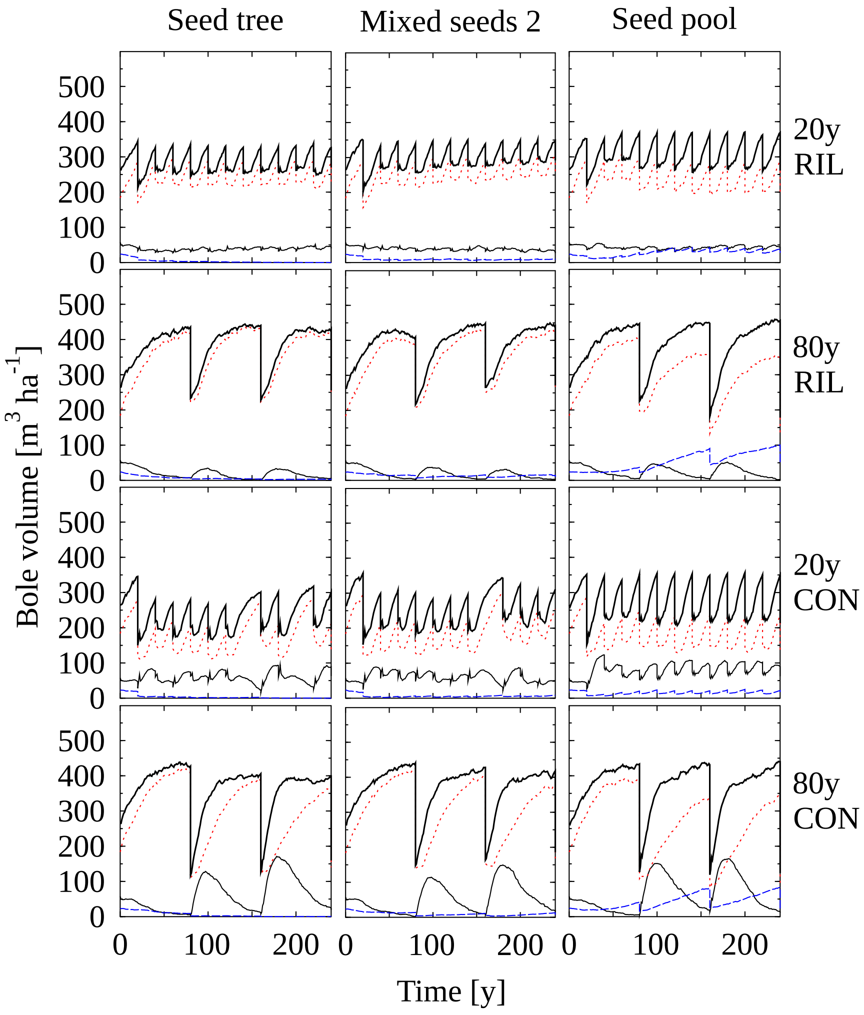
Impact of different logging scenarios on forest. Damages depend on area position within forest.

Impact of different logging scenarios on forest.

	Effects	RIL	CON
1	Felling damage	∼crownsize	
2	Felling direction	gaps	random
3	Skidding damage	25%	55%
4	Area loss	12%	33%
5	Mortality 10yr after	× 2	× 3

Results

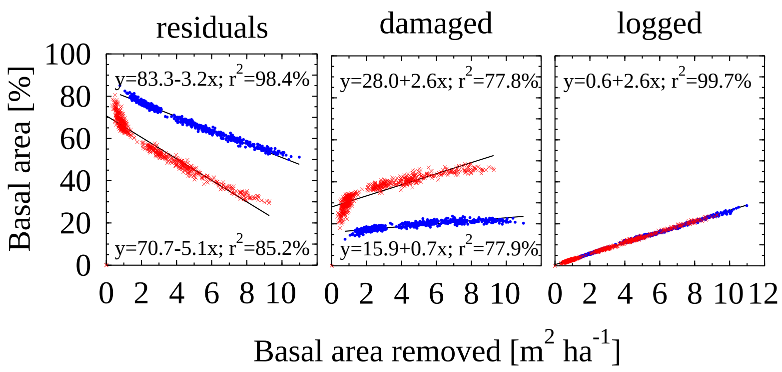
Surprisingly, recruitment assumptions do not influence quantity of harvest yields, but its quality as species composition is biased towards mid successional species in seed tree scenarios. Yield were maximised in long logging cycles and reduced impact logging strategy. Some examples of forest dynamics of shown in following figures.



Development of bole volume (m^3 ha^{-1}) for different scenarios. Simulation of 9 ha over 240 y (n=5) of logged forest. Variation of logging cycle (20 y; 80 y), strategy (RIL: reduced impact; CON: conventional) and recruitment scenarios (seed tree; mixed seeds 2; seed pool). **Total**, early successional spp., mid-successional spp., late successional spp.

It is not clear if and how seed dispersal will alter in response to high fractions of early successional species as seen in most conventional scenarios. Habitats of most animals acting as seed dispersers or predators are altered and their futures are uncertain. Thus, we understand our results as very optimistic.

Simple relationships of logging impacts as function of logging intensity emerge from analysis. They are easily comparable with field data and validate our analysis as reasonable. Furthermore, they are a practical tool for estimating impacts of human disturbances on residual forests.



Effects of different logging strategy (reduced impact, conventional) and intensity on the forest structure. Basal area (residuals, damaged, logged) as function of removed basal area.

Conclusions

FORMIND2.0 is able to analyse various logging strategies with respect to their impacts on residual rain forest. Reduced impact logging strategies with cycles length of 80 years gained highest timber yields. However, in highly fragmented landscapes long term recruitment of most tree species is questionable. As recruitment is important for species composition large disturbances of any kind threaten late successional tree species with extinction.

References

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