Center for
Environmental Systems Research

T. Ditzer[†], M. Förster[‡], P. Köhler[†], R. Glauner[‡], A. Huth[†]

[†]Center for Environmental Systems Research, University of Kassel, D-34109 Kassel, Germany
[‡]Institute for World Forestry, Federal Research Centre for Forestry and Forest Products, Leuschnerstr. 91, D-21031 Hamburg, Germany

Introduction

Tropical forest management is at a crossroad. Long-term field data to determine timber growth, to fix Annual Allowable Cuts (AACs), and to assess forest disturbance are widely not available. This problem can be bridged by growth models which provide a valuable tool supporting yield regulation.

Presently only few operational models exist for tropical rain forest. Such models simulate forest dynamics in stands of approx. 1 ha. We use the model FORMIX in a GIS-framework to support forest management decisions on the larger scale of field operation. This poster presents our concept of how to apply FORMIX for the 55.000 ha of Deramakot Forest Reserve in Sabah, Malaysia.

Approach

FORMIX is a process-based model developed for ecological studies and management planning in the Dipterocarp forests of South-East Asia (Huth et al. 1997). Typical for Malaysia, the Forest Management Units (FMU) cover areas of commercial forest of approximately 100,000 ha. Within the FMU site conditions, actual growing stock, and forest structure vary considerably, especially in heavily logged and partially degraded forests as found at Deramakot.

Our approach considers the FMU as composed of single and mutually independent 0.1-2 ha-stands differing in site conditions and forest structure. We classify site characteristics and actual growing stock to derive a set of *site-specific stand types (SSSTs)* and analyse their particular present stand structure.

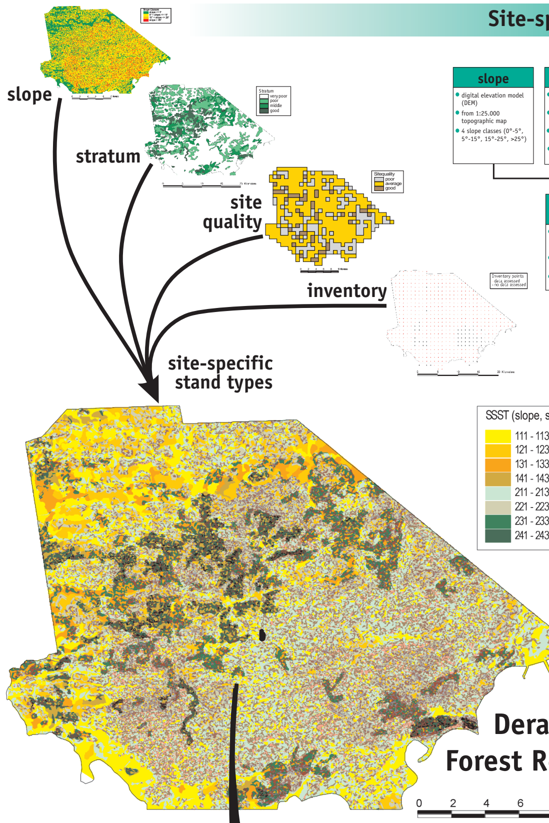
The model FORMIX is parametrized for the site conditions reflected in the SSSTs. In simulation, the range of site conditions given at Deramakot determines the *potential vegetation*. Based on the SSSTs, the regeneration of the disturbed *present vegetation* is simulated.

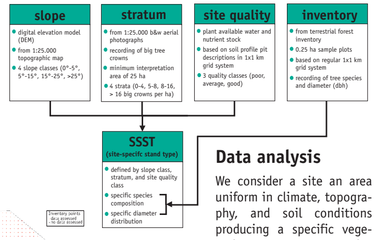
In the *exemplary simulation of potential timber harvests* we compare different logging strategies to evaluate timber yields and the effects on forest structure.

Conclusion

Silvicultural decisionmaking needs support for planning the management of large, heterogeneous areas. Evaluation of forest resource condition and forest growth for developing sustainable management strategies must account for this heterogeneity. The joint application of a detailed stand growth model and spatial data analysis in a GIS provides a suitable approach to this task.

Site-specific stand types (SSSTs)





Data analysis

We consider a site an area uniform in climate, topography, and soil conditions producing a specific vegetation structure, species composition (forest type), and a particular yield.

The description of sites at Deramakot is based on topographic maps, aerial photo interpretation, soil data measured in the field, and a terrestrial forest inventory. These data are captured in a GIS (Geographic Information System) and underly the determination of site-specific stand types (SSSTs).

The SSSTs are based on an analysis of slope gradients (4 slope classes), growing stock (4 stocking strata), and of water and nutrient status of the soil (3 site quality classes). The combination of these geographic layers (*maps on the left and flowchart above*) results in 48 theoretical SSSTs out of which 44 are actually found at Deramakot.

From the terrestrial inventory data a representative tree diameter distribution is derived for each SSST.

The model FORMIX

The calculation of tree growth is mainly based on light-response characteristics of net photosynthesis and a simple model of tree physiognomy. Tree species are grouped into 4 functional species groups (emergents, main canopy species, pioneers, understorey species) and the model is subsequently parametrized based on field data.

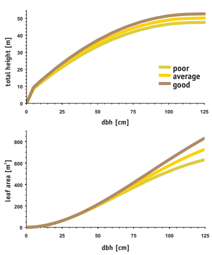
Parametrization

Site quality affects the typical physiognomy and average increment of trees. We apply a growth factor (*table below*) derived from diameter increment measurements to reflect the effect on total increments. Height-diameter-curves and leaf area in its relation to diameter for differing site qualities (*figures below on the left*) can be derived from field data as well.

The effect of slope gradients on forest dynamics is more hypothetical. We assume higher propability of gap formation and less effective light attenuation on steeper slopes.

Growth factor applied to diameter increment on sites of different quality

species group	site quality: poor	average	good
emergents	-10 %	±0 %	+10 %
main canopy species	-13 %	±0 %	+13 %
pioneers	-25 %	±0 %	+25 %
understorey species	-11 %	±0 %	+11 %



Physiognomic relations of trees on sites of different quality (height diameter curve for emergents)

Potential vegetation

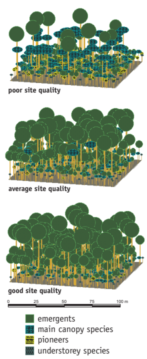
Simulated mature forest structure dependent on site

Long term simulations of forest development are used to analyse the potential, mature forest structure. Based on the site classification, the model predicts mature forest structure on sites of different slope and — most important — site quality.

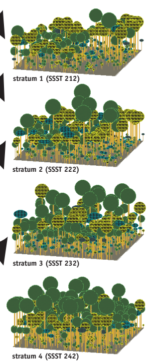
The *stand pictures on the right* show simulated 1-ha mature forest stands on sites with differing qualities and slope of 5°-15°. The *table below* summarizes several structural variables.

Simulated mature forest structure on sites of different quality and slope 5°-15°

		site quality: poor	average	good
total abovegr. biomass	[t ODM ha⁻¹]	232	451	516
basal area (> 10 cm dbh)	[m³ ha⁻¹]	21.1	30.5	35.6
stem number (> 10 cm dbh)	[ha⁻¹]	766	753	819
standing vol. (> 10 cm dbh)	[m³ ha⁻¹]	206	385	438
stem number (> 60 cm dbh)	[ha⁻¹]	7	23	25
standing vol. (> 60 cm dbh)	[m³ ha⁻¹]	66	225	237

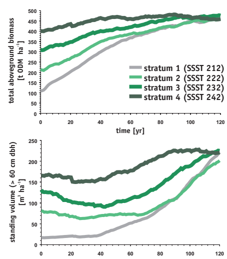


Present vegetation



Simulated forest regeneration of SSSTs

An undisturbed development of the forest at Deramakot is simulated. Simulations are performed for each of the SSSTs. The tree diameter distribution derived for each SSST initializes the simulation (examples in the *pictures on the left*). The SSST's site quality and slope characterize the site conditions. The *figures on the right* show simulation results for the forest regeneration projected for the four strata on sites of average quality and slope 5°-15°.



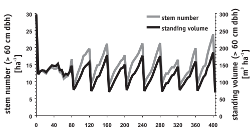
Simulated forest regeneration of selected SSSTs representing the four strata of actual growing stock

Exemplary simulation of potential timber harvests

Reduced impact logging (RIL)

We simulate a RIL-technique: only commercial species > 60 cm dbh are harvested, 5 of these harvestable trees are left in the forest to foster natural regeneration, and low logging damages are assumed. A site with average quality and slope of 5°-15° is simulated.

The *figure on the right* shows the stem number and standing volume (clear bole vol.) of trees of harvestable dimension in a stand logged every 40 years with a 20 % stand damage.

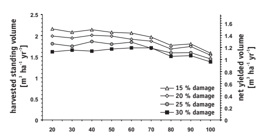


Simulated standing volume and stem number of trees > 60 cm dbh in a RIL-scenario with 20 % damage and a 40 year cycle on a site of average site quality and slope 5°-15°

Comparing logging strategies

Simulations as described on the left allow for comparing different logging strategies. *The figure on the right* depicts results for different scenarios of RIL, applying damages of 15 % - 30 % and logging cycles of 20-100 years.

Such analysis helps to investigate the effects of silvicultural decisions on timber yields and forest structure. Once a logging strategy is selected, the respective AAC will (in future work) be determined in the GIS-framework.



Simulated standing volume of harvested trees and the assumably 30 % smaller net timber yield at roadside for different RIL-scenarios on a site of average site quality and slope 5°-15°

References: Huth, A., T. Ditzer, and H. Bossel, 1997: Rain Forest Growth Model FORMIX3. German Agency for Technical Cooperation, Eschborn, Germany. (available at http://www.gtz.de/toeb/ftp/formix.pdf)

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