MODELLING NATURAL FOREST GROWTH AND YIELD IN ECUADOR

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SUMMARY

The natural forest growth model CAFOGROM is demonstrated with five examples of different management regimes based on projected growth of EMBRAPA research plots at Tapajos in the Brazilian Amazon. These suggest that to be sustainable with a limited species base, logging must be strictly limited to a maximum of 1 m3/ha/yr. This implies felling a maximum of 20 m3/ha/yr if a 20-year felling cycle is imposed. The felling cycle decision can be eliminated using stand basal area as a criteria to permit felling, with a lower limit of 27 m2/ha suggested. Under this condition, average felling cycles may be 30 years given well-controlled logging. It appears likely that selective stand treatment may be desirable to ensure growth and maturity of smaller-sized valuable trees. It is important to adapt this model to the Ecuadorian western lowland forests using the permanent sample plots established by the Fundacion Forestal, so that there may be some reasonable guidelines for forest management in Ecuador.

INTRODUCTION

In this presentation, I am going to discuss some concepts relating to the potential timber yield of natural tropical forests. This discussion will be based around a demonstration of the CAFOGROM forest growth model which was developed for the natural forests of the Eastern Amazon in conjunction with Dr. Natalino Silva. Dr. Silva has also been a consultant to FFJMD[1] and has advised on the design of PSPs and set up data processing systems for the La Mayronga ITTO[2] project. This will make the adaptation of CAFOGROM to results from the La Mayronga PSPs[3] quite simple, once the plots have been re-measured after about 5 years. However, for this presentation, we are seeing growth data and results that relate to the species and fertility conditions of the Eastern Amazon.

A BRIEF DESCRIPTION OF CAFOGROM

A full technical description of CAFOGROM is given in a paper by Alder & Silva (1999). The model is based on work by Vanclay (1989) for a model of the rainforests of North Queensland. I originally adapted those ideas to a first version of CAFOGROM in 1994 (Alder, 1995). The concepts of the model were then refined further from two other regional studies, from Costa Rica and Papua New Guinea. In Costa Rica I worked with CODEFORSA under a DFID[4] project to develop a model called SIRENA (Alder, 1997). In Papua New Guinea, a related model was developed called PINFORM, based

[1] Fundacion Forestal Juan Manuel Durini
[2] International Tropical Timber Organisation
[3] Permanent Sample Plots
[4] Department for International Development of the United Kingdom

on 72 PSPs established and re-measured under an ITTO project there (Alder, 1998). Finally, in this cycle of refining and improving a model concept, CAFOGROM itself has undergone two major revisions, associated with a re-analysis of the data and improvements in the model structure, to achieve the version 3.05 that will be demonstrated today.

Like the related models, CAFOGROM is strictly empirical in concept. It uses functions of diameter increment with tree size, tables of mortality, tables of recruitment (regeneration) and stand level functions that modify the levels of increment, mortality and recruitment depending on the degree of disturbance. Also, and very importantly, there are functions of logging damage, based on observations from the PSPs. These indicated in some detail how logging will affect the survival of different size classes based on the degree of disturbance. All of these functions are based on analysis of data from some 200 PSPs measured over 15-17 years by the Brazilian federal research institute EMBRAPA Amazonia Oriental in Belém (Silva, 1989; Silva et al., 1995, 1996).

The many species which are recognized on the PSPs from the Tapajós and Jarí areas (1000 or more) are grouped in the model into 56 growth model groups. This table can be viewed in the model. The various groups are then reclassified for reporting and output purposes into a number of simple management groups indicated by the letters A, B, C etc. These groups can be modified by the user to reflect different levels of commercial value or as ecological indicator species such as extreme pioneers, shade bearing species, and so on.

The model allows various options for management, especially the intensity and frequency of harvesting, a silvicultural removal of non-commercial trees, to be tested on inventory data for a particular forest. The forest is 'grown' over several felling cycles, and it is possible then to review the sustainability and level of yield that may be obtained under the proposed regime.

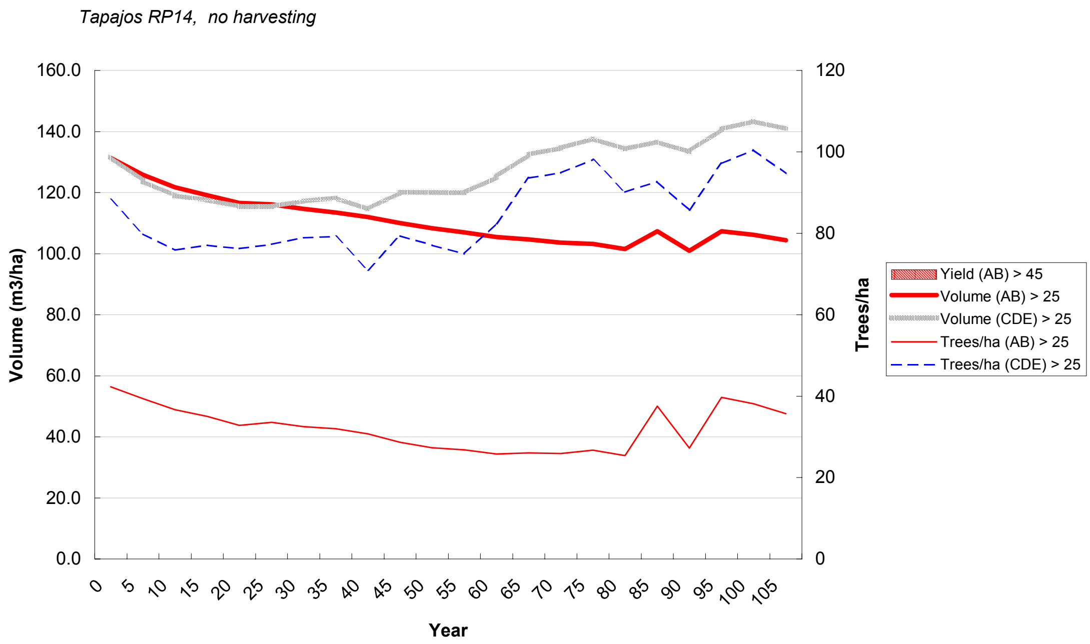
CAFOGROM allows different time intervals for projection to be tested, which may be one to five years or more. In each period, the processes of diameter increment, mortality, recruitment, and possibly simulated logging or stand treatment, are applied. These are then repeated for the next step, until the time limit is reached. Short time steps (one to two years) give the most accurate results, but up to five years, the model functions reasonably well. A five year interval is faster for demonstration, and is used in the examples presented here.

CAFOGROM (in common with its siblings, SIRENA and PINFORM) produces a variety of outputs which are designed to allow the internal mechanics of the model to be studied in detail, and to give good indications regarding the sustainability and impact of a management regime. These outputs are provided as graphs, and are also available for exportation as tabulated data to other packages. These various output figures also help us to learn about the complexities of managing natural forest.

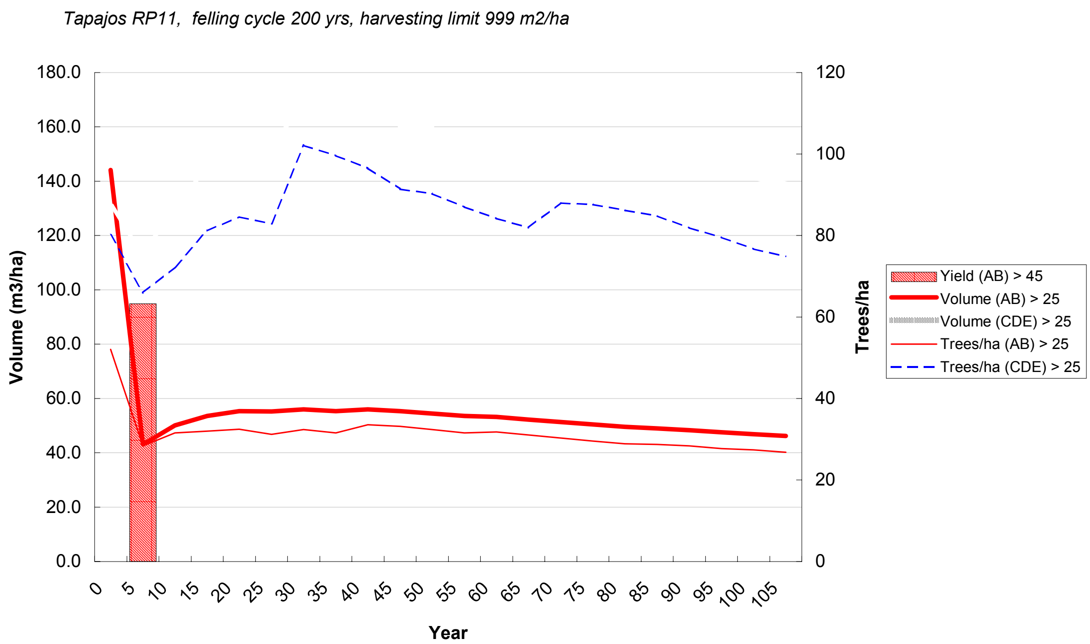
EXAMPLE 1 : PROJECTION OF AN UNDISTURBED NATURAL FOREST

The research plots at Tapajós RP14 , which are virgin forest control plots, are simulated in example 1 without logging or treatment over 100 years. The volume of commercial trees over 25 cm dbh starts at about 120 m3/ha, and declines over time.

The non-commercial trees have a similar volume, and tend to increase slowly over time. The number of commercial trees is about 40/ha, whilst the non-commercials are about 100/ha, indicating the latter tend to be smaller.

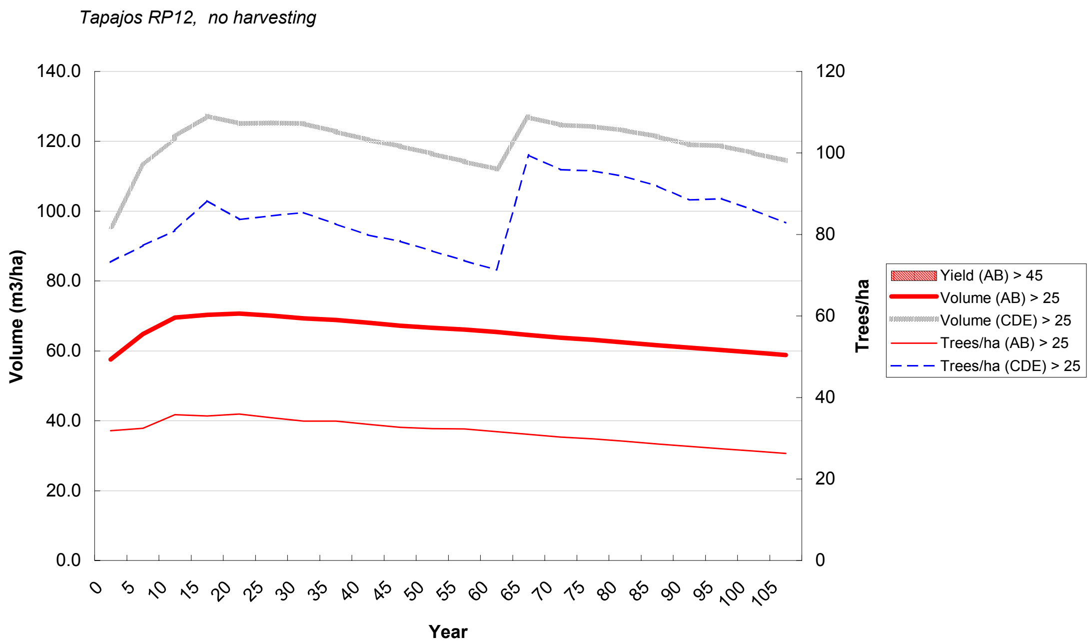


In general, for this virgin forest without logging, there is an equilibrium over time with no great net increment, but gentle fluctuations due to the internal dynamics of stand structure, competition, mortality and so on.



EXAMPLE 2 : RECOVERY OF HEAVILY LOGGED FOREST

Two examples will be illustrated for different sites and having different species composition. The first from RP 11 is at the same location as RP14, and therefore a similar site. However, RP 11 was very heavily logged (about 90 m3/ha extracted) in the first 5-year period of the simulation, corresponding to the removal of all commercial timber over about 50 cm diameter. It can be seen that whilst volume recovers quite rapidly over 30 years, it is almost entirely composed of non-commercial species, and commercial volume remains static over the 100 year simulated period.



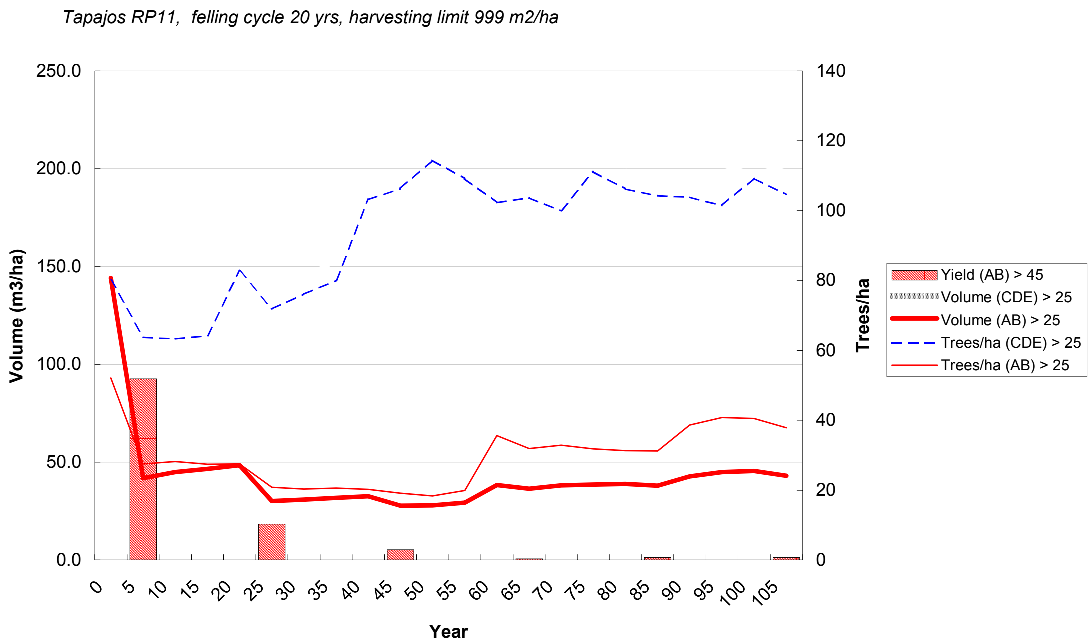
RP 12 is some 60 km distant, was logged a little less heavily (70 m3/ha extracted) and contains a different mixture of species, with *Jacaranda copaia* being especially abundant. This results in a more rapid growth of commercial timber, but again, as the diagram shows, as the stand reaches full stocking, net growth is curtailed, and there is no evidence of recovery to the original volume of commercial stock.

Both these simulated cases have been analyzed in detail over a 15-17 year period in Alder & Silva (1999). For the period for which there is comparison data between the model and PSPs, the model is quite accurate, and there is little reason to doubt these simulations.

These forests recover from a heavy logging to their original total volume quite quickly (within 30-40 years), but it is mainly composed of non-commercial species.

EXAMPLE 3 : 20-YEAR FELLING CYCLE WITHOUT TREATMENT

Since the forest growth appears to become static some 20 years after logging, we can simulate the effect of a simple uncontrolled 20-year cycle, using RP11 as our example.

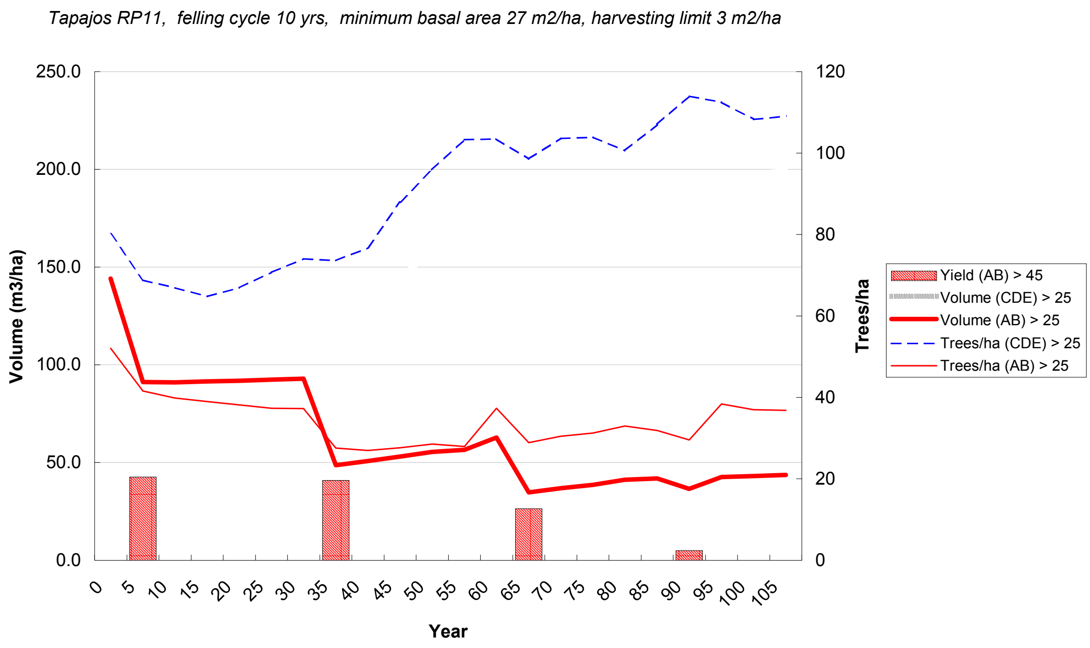


As can be seen, with this scenario, there is little evidence that there will be a useable harvest above 50 cm dbh for subsequent cycles after the second. There are three problem areas. Firstly, the first logging, taking all commercial timber above 50 cm from the commercial forest, is too heavy and destructive. Secondly, the regeneration and growth rate of the commercial trees is insufficient. Thirdly, the growth of non-commercial timber is rapid and creates heavy competition for the commercial species, encouraging them to stagnate.

Example 4 : Basal area control of felling

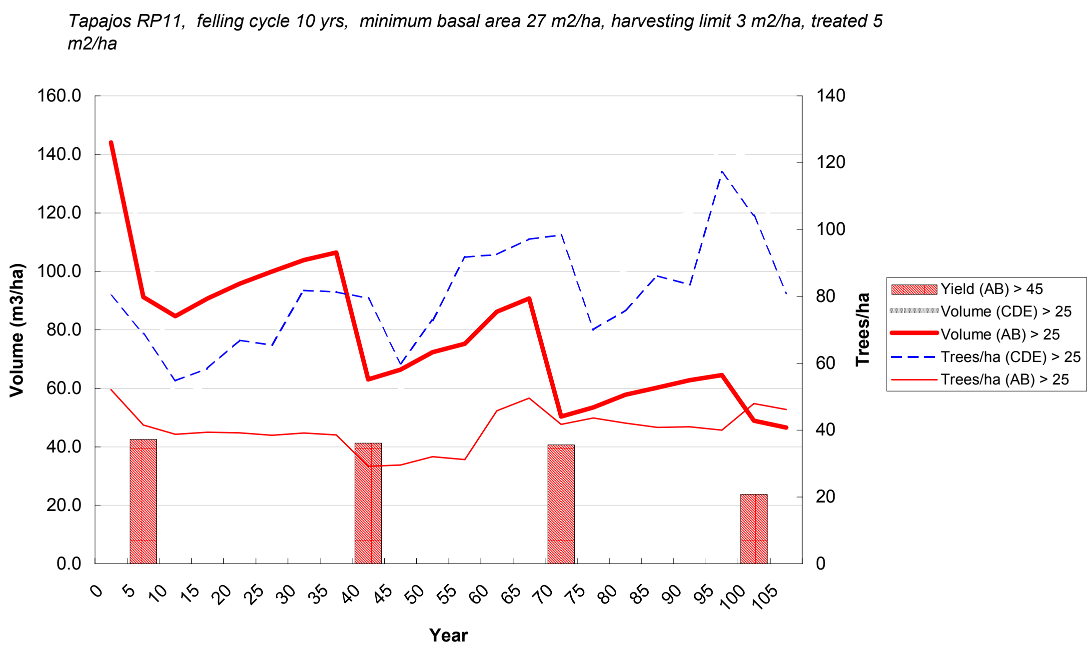
To avoid the problems associated with an unknown felling cycle and excessively heavy initial felling, we can control the management using basal area as a criterion. Example 4 shows a situation where RP11 is managed with a 27 m2/ha minimum felling basal area, and a 3 m2/ha maximum limit for harvesting.

This results in a felling cycle of approximately 30 years, and with volume removals in the first two cycles of about 40 m3/ha. There is still a problem of the accumulating biomass of non-commercial timber which is suppressing the growth of commercial species.



EXAMPLE 5 : THE EFFECT OF STAND TREATMENT

The next example illustrates the effect of stand treatment. The basal area of competing non-commercial trees is reduced by 5 m2/ha. This leads to some improvements in growth of the commercial species. It can be seen by comparison with example 4 that the third and fourth cycle yields are higher, but it still appears that this relatively heavy thinning is insufficient to ensure sustainability.



There are several difficulties with stand treatment. The benefits, when compared with untreated management, are only realised after some 40-50 years. This implies that for a financial calculation, the costs of treatment must be compounded over that period of time. There are likely to be strong objections to the application of stand treatment on a broad scale from conservationists, and probably with good reason: The use of poisons, the reduction in biodiversity, the elimination of plants important to wildlife and the dangerous nature of a forest stocked with numerous standing dead trees.

CONCLUSIONS

The model demonstrated here is designed for research applications in forest modelling, and is somewhat over-complex for basic forest management applications. For use in Ecuador, it also needs to be parameterized for local species and growth conditions. This requires a base of permanent sample plot data, together with appropriate forest inventories that sub-sample down to 10 cm diameter or smaller.

True sustainable forest management in natural forest appears likely to be a complex matter requiring careful and knowledgeable management, effective control of operations in the forest, and significant financial inputs into silvicultural treatment and enrichment planting of valuable species to supplement natural regeneration.

In the short run, four practical aspects clearly need to be developed:

- Control methods to limit harvesting to approximately 20 m3/ha, assuming a 20-year felling cycle (a maximum of 1 m3/ha/yr).
- Methods of enrichment planting with valuable but fast growing species in felling gaps and log landings.
- Methods of liberating medium and pole sized trees of high commercial value.
- Reduced-impact logging methods.

All of these require a very pro-active and intensified forest management, together with considerable knowledge at the technical and local level. Implementing such systems in natural forests will be the challenge of the next generation.

In general therefore, natural forests should be sources of low volumes of wood for high value conversion, and can be conserved and managed sustainably only through strict controls on logging intensity and method.

For wood supply for industry, natural forests can provide only a temporary solution. Long-term supply must be managed through the creation of plantations.

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