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SECONDARY FOREST DYNAMICS AND MANAGEMENT FOLLOWING PAPER PULP CUTTING IN FRENCH GUIANA

J. F. LACOSTE and D. Y. ALEXANDRE

Tropical rainforests have important biological and economic values, but are very complex and fragile. Exploitation of forest resources has led to large deforestation resulting in serious ecological and economic problems. Some countries, traditionally exporters of forest products, such as Ivory Coast, have become net importers (Bertrand 1983). Amazonian forests still largely undisturbed thanks to their huge extension are in fact endangered by modern technology.

Forest regeneration has always been at the heart of foresters' preoccupations (Catinot 1965). Artificial regeneration has its partisans, but due to large uncertainties regarding ecological consequences and economic costs, natural regeneration appears to be more acceptable (Fox 1976).

This study was conducted in French Guiana a country where 90% of the land is still covered by undisturbed forests. Lumbering is not of concern yet, but it may be of importance in the future as in other countries where wood exploitation has led to predominantly useless secondary formations. Our goal was to improve present understanding of secondary forest dynamics with an applied perspective.

After cutting a tropical rainforest, secondary regrowth is characterized by the dominance of a few small tree species with a large number of individuals (Richards 1952, Whitmore 1975). In French Guiana these species belong to the families Cecropiaceae, Cluisaceae, Flacourtiaceae, Celastraceae, Melastomataceae, Rubiaceae, and Solanaceae (De Foresta 1981; Prevost 1981). Most species are typically short-lived. But some other are long-lived belonging to the "cicatricielles durables" of Mangenot (1956), "nomad" of Van Steenis (1956), or "late secondary" of Budowsky, 1965). These species are of considerable economic interest (Taylor 1960, Kahn 1980).

In our study area the most prominent species of this group are *Goupia glabra* Aubl., *Jacaranda copaia* D. Don, *Bagassa tiliaefolia* R. Ben, *Carapa guianensis* C. DC., and *Simarouba amara* Aubl. During early stages of forest succession they appear in fairly large densities but disappear almost completely later on. They have to withstand a fierce competition with short-lived but faster growing sun-loving species. At the end they may remain as isolated individuals among the dominating species of the late successional forest.

According to current succession models the timely erradication of short-lived species can favor the growth of valuable species and lead to an enriched forest. Attempts in this direction have been made by Schulz (1960) in Suriname. This study is focused on *Goupia glabra* because of its abundance and ecological characteristics (Leroux 1983).

Site Descriptions, Materials, and Methods

This study is part of the ECEREX project aimed at the analysis of forest recovery after paper pulp cutting (Sarraihl 1980, 1984) and was conducted in the catchment basin "D" (1.8

Jean-François Lacoste **studied at the University of Orsay (France). He began his resarch in tropical ecology when he went to French Guiana in the ORSTOM Ecological Laboratory in Cayenne. He worked there for three and a half years as part of the MAB ECEREX Project. At present, he is completeing his Ph. D. (Doctoral en Ecologie Végétale) in Orsay. Address: Universite de Paris-Sud laboratoire d'Ecologie Végétale Bât. 362 91405 Orsay Cedex, France.**

Daniel-Yves Alexandre **studied in Paris where he got his Doctorat ès Sciences Naturelles. He is a research fellow in the French Institute of Scientific Research for Development in Cooperation (ORSTOM). Formerly in Ivory Coast where he participated in the MAB Taï Project, he spent 5 years in French Guiana, where he is head of the ORSTOM Ecological Laboratory in Cayenne. His main interest is the application of basis research to agricultural problems. Now back in France, he is planning a program for the Sahelian zone in Africa. Address: ORSTOM, 213, rue La Fayette 75480 París CEDEX 10, France.**

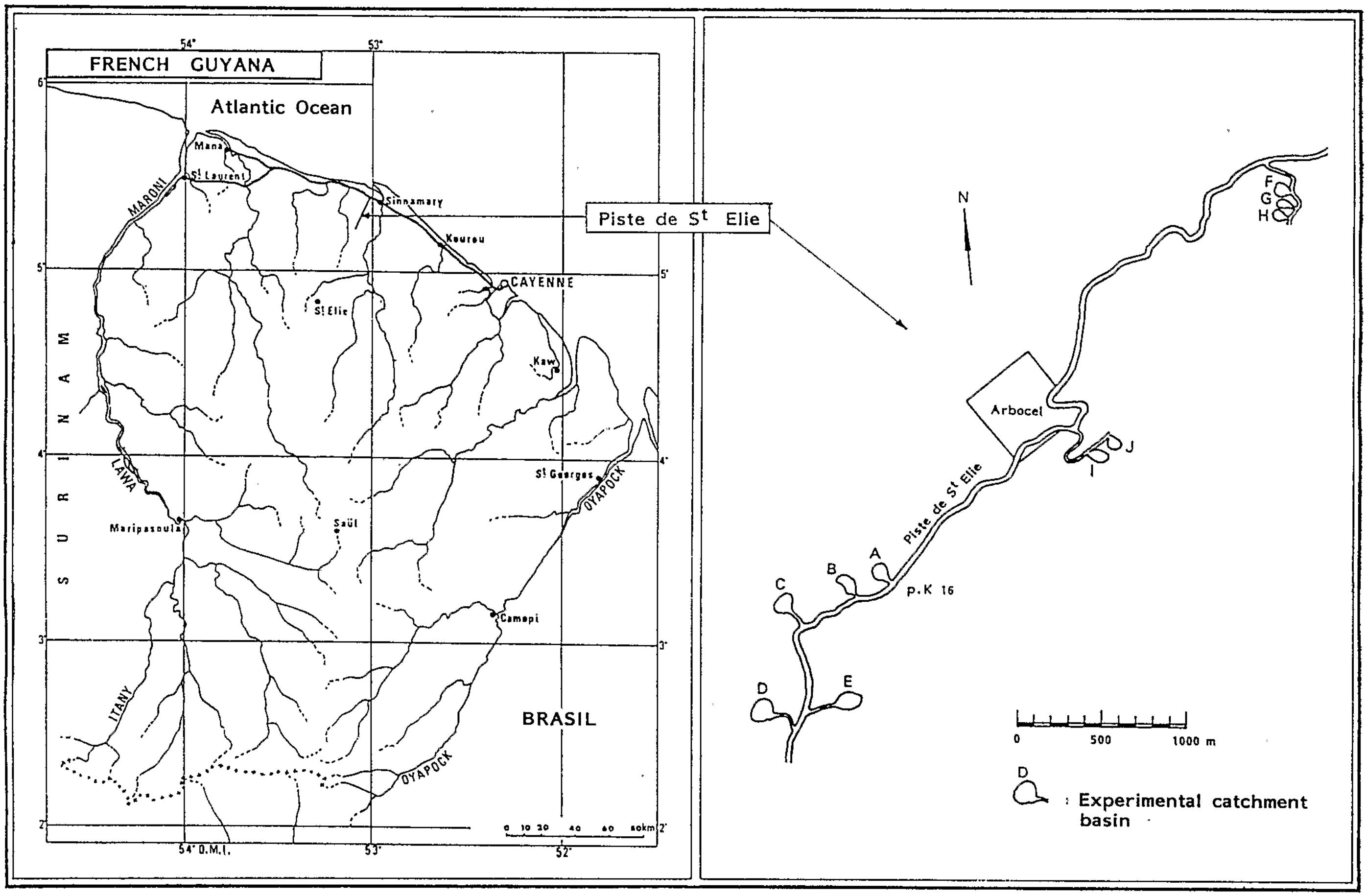

Figure 1. Geographical situation of the study area.

ha) under natural regeneration management (Fig. 1) (Lacoste 1985).

Climate has been described as "equatorial de type guyanais" (Boyer *et al.* 1978). Mean annual rainfall averages 3086 mm with a distinct dry season (August-November) and a variable dry spell locally known as the "petit été de mars" (February-March). The interannual variability is high as shown by the frequence analysis of rainfall (Fig. 2).

Soils belong to the ferralitic unsaturated type (Blancaneaux 1978). Thorough physical analyses revealed the local high frequency of impeded drainage at variable depth (Boulet 1978, 1980; Boulet *et al.* 1979) leading to the differentiation of two main soil types: "sols à drainage vertical bloqué" or DVB where the water flux is mostly shallow and lateral, and "sols à drainage vertical libre" or DVL for those without physical constraints for vertical water flux. These physical characteristics were supposed to be of importance for forest management. The basin "D" was appropriate to conduct this study, because the eastern side was on DVB soil while the western side was on DVL soil. Experimental plots were distributed according to soil differentiation as shown in Fig. 3.

After forest cutting in 1980 only a few remaining trees were left standing (species unusable for paper pulp). Boles were bulldozered and a few left on the ridge top. The whole area was then left to natural regeneration. The experiment was set up in 1982 by M. Leroux under the supervision of J. P. Lescure. The upper half of the basin was treated while the lower half was left as control. The treatment consisted in pulling out all individuals of undesirable species because of their fast growth and potential harmful effect upon valuable species. The species eliminated were: *Cecropia obtusa, C. scyadophylla, Vismia sessilifolia, V. guianensis, V. latifolia,* and *Solanum* spp.

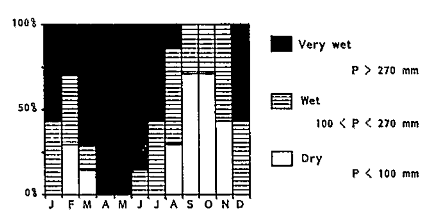

Figure 2. Frequential analysis of monthly rainfall data (P) on study area (from 1978 to 1984).

In each of the four areas defined by soil types and treatments three 10 x 10 m permanent plots were delimited (Fig. 3). The plots named from A to L are mapped to scale in Fig. 3. Every individual over 1.30 m was tagged and numbered. Stem girth was measured monthly during 5 years.

The large heterogeneity of the vegetation was hard to deal with. Distribution of secondary species and remnants was very uneven. The permanent plots were set so that several individuals of *G. glabra* were included.

Water content at wilting point, current soil water content, and apparent soil density were measured by Desjardins (1986) using rain gauges, neutron humidity probe tubes and tensiometers located 15, 30, 50, 80, and 140 cm depth were set in the plots J, F, D, C, A, and I.

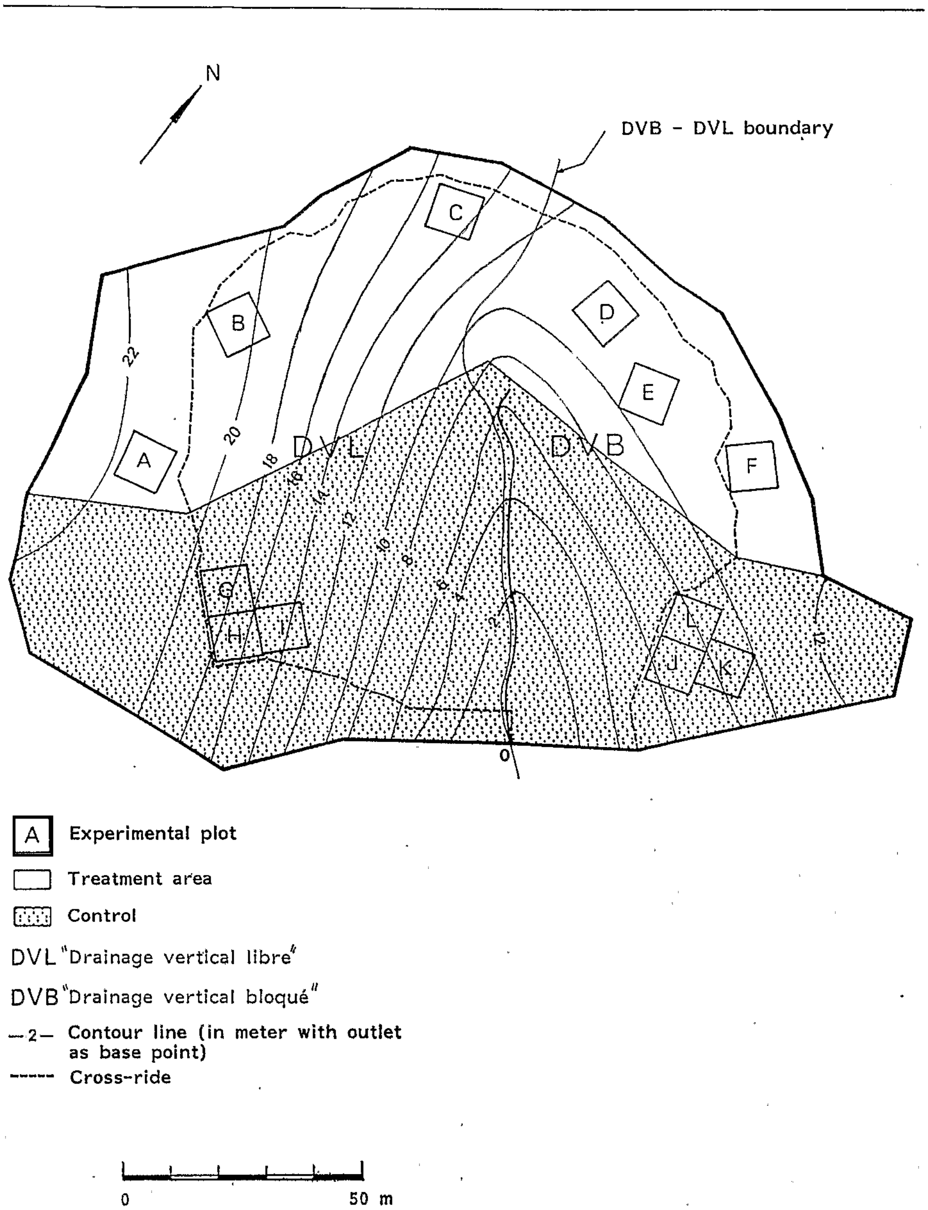

Figure 3. Watershed "D". Location of experimental plots.

Five additional plots not influencing the permanent plots were harvested to compute allometric relations for the estimation of biomass, height and vertical distribution of Leaf Area Index (L.A.I.). In the sampling plots each individual was felled, cut in 1 m sections, separated in leaves, branches and trunk, and dried at 105°C until constant weight. For each species and stratum the area of 50 leaves was measured with a LICOR LI3000A followed by dry weight determination to calculate the leaf weight/area ratio. Full inventory of the basin was conducted in December 1987 for individuals over 5 cm diameter.

Results

Seasonal variations of soil water content

The soil profile showed a fairly constant water content except during pronounced dry spells (Desjardins 1986). But even during the weak dry season of 1986 the permanent wilting point is approached all over the soil profile of a plot on DVB soil (Fig. 4a). Rewetting of the soil profile in the same station occurred very rapidly after rain return (Fig. 4b). The tension profile never reached the value corresponding to field capacity indicating that in spite of impeded drainage, no water table was formed in DVB soils. This may be a consequence of slope and probably explains in part the results obtained on growth rates.

Girth frequency distribution of Goupia glabra

Four and a half years after treatment the number of individuals measured in thinned plots was twice as high as that of the control. At this time larger saplings in the treated areas were over 30 cm in girth whereas they did not reach 15 cm in the control (Fig. 5). In both cases girth distribution showed a log-normal tendency indicating strong competition. Results from DVB and DVL soils were not statistically different.

Leaf biomass profile

After 6.5 years the vertical profile of leaf biomass was measured in two 25 m² plots in the control area (Fig. 6a) and three 25 m² plots in the treated area (Fig. 6b). In the con-

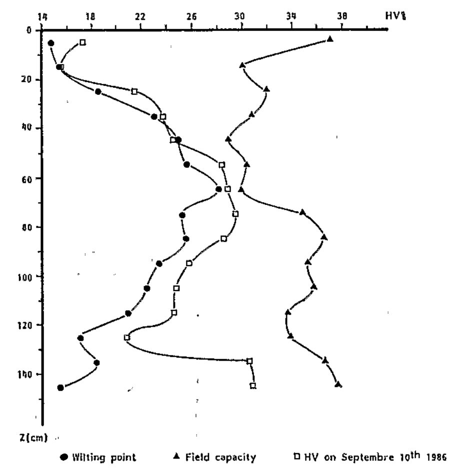

Figure 4a. Soil volumic humidity (HV) profile in plot 'D" (DVB) on September 10th 1986 (in DESJARDINS 1986).

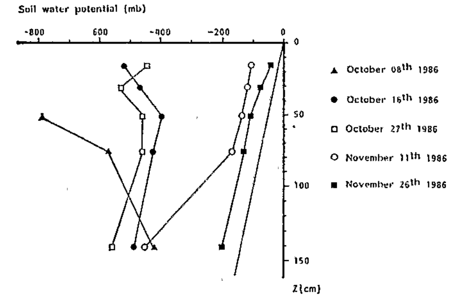

Figure 4b. Soil water potential evolution (plot "D") at the onset of rainy season (in DESJARDINS 1986).

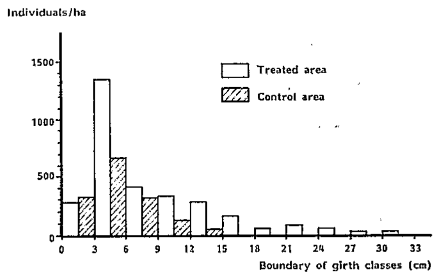

Figure 5. Girth frequency distribution of Goupia 4.5 years over forest management.

trol plots 4 species contributed more than 95% of the total leaf biomass (TLB) from which 59% correspond to the *Cecropia* species, 20% to *M. fragilis* and 16% to *L. procera.* Most leaves were found in the upper canopy layers:

Height above soil level (m)	*% of TLB*
18-15	40%
18-14	64%
18-11	90%

This leaf biomass distribution reflects the monolayered stratification of the 6.5 yr old regrowth. Leaf biomass density decreased evenly from the top except the lowest meter where seedlings and young palms constituted a noticeable stratum.

Removing of *Cecropia* spp. in the treated plots increased the dominance of *M. fragilis* (65.5% of TLB) and *L. procera* (21.8% of TLB) thus stressing the monolayering. *Goupia glabra* contributed 2.9% of TLB in the treated plots compared to only 0.6% in the control plots. The upper 3 meters of canopy accounted for 80% of TLB in the treated plots. Miscellaneous species contributed 8.7% of TLB, all in the lower 5 m, in the control plots, against 4.8% in the treated plots, found mostly in the undergrowth. The abundance of *M. fragilis* in the stand is due to the seed crop from a few mature trees growing in an old gap in the vicinity (De Foresta and Prevost 1986).

On a per ha basis TLB in the treated plots reached 4.3 t/ha vs 7.3 t/ha in the control, almost a twofold ratio. However, the leaf area index is similar in both cases reaching 5.5. This discrepancy between TLB and LAI is explained by the large proportion of *Cecropia* spp. leaves biomass in the control plots (about 60%) with weight/area ratios roughly twice as high as in the other species. The petioles of *Cecropia* spp. leaves account for 30% of total leaf biomass. Once again no differences between soil types were detected.

Growth of Goupia glabra

Figure 7 shows the growth of *Goupia glabra* during an 8 months period from April to December 1986, i.e. 3.5 years after the treatment. The only saplings which showed a significant girth increase during the observation period were found in the treated plots; however, most saplings in both plots did not grow at all. Diameter increase was significant only in those saplings with girth size over 15 cm. No significant differences were detected between soil types.

Discussion

The factorial experiment described above was designed to measure the effect of impeded drainage and competition removal on the growth of an economically important late successional species, *Goupia glabra*. The data showed that growth of this species on DVB soils was not affected. This may result from the slope of the basin which avoids the formation of a perching water table, or from the particular root morphology of this species. We have observed that roots of *G. glabra* can penetrate deeper soil horizons than other

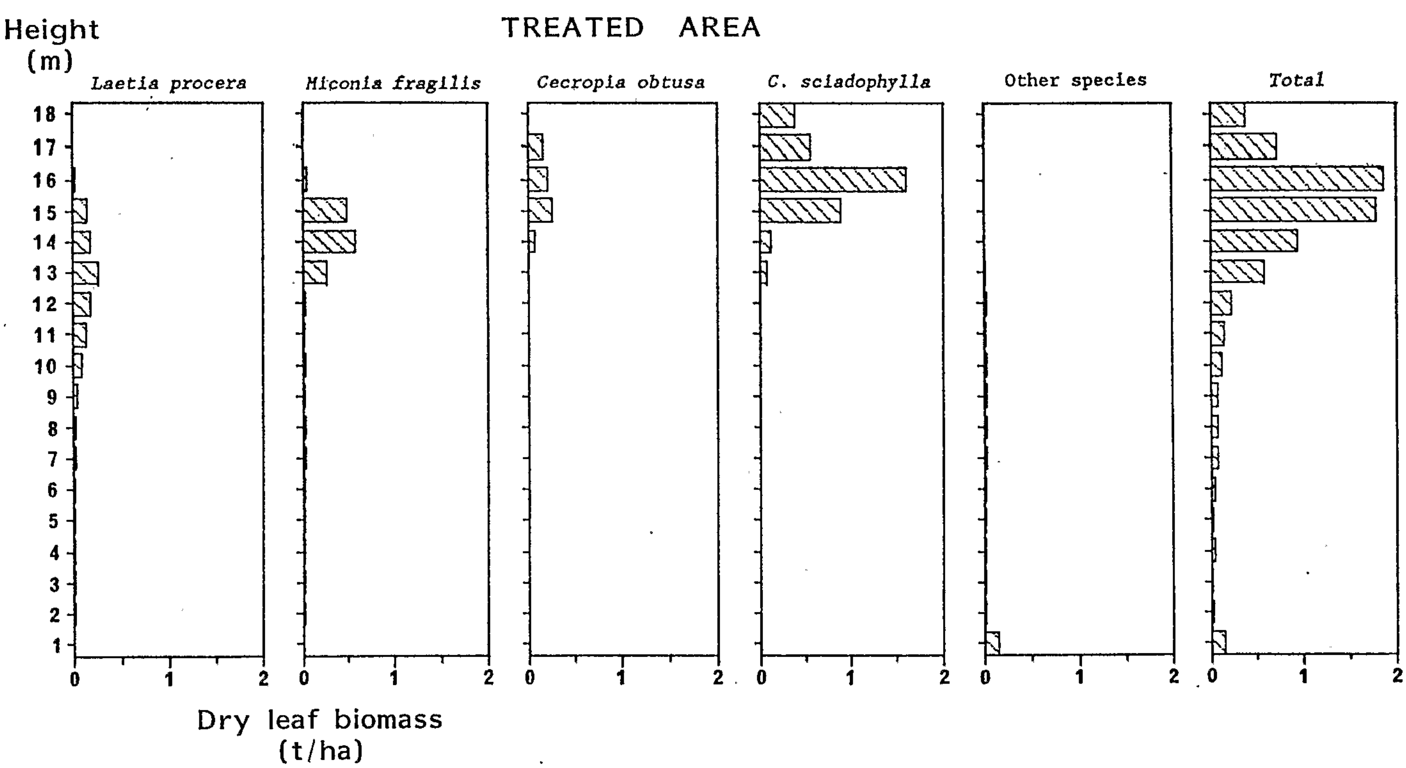

Figure 6a. Vertical leaf biomass distribution in control area.

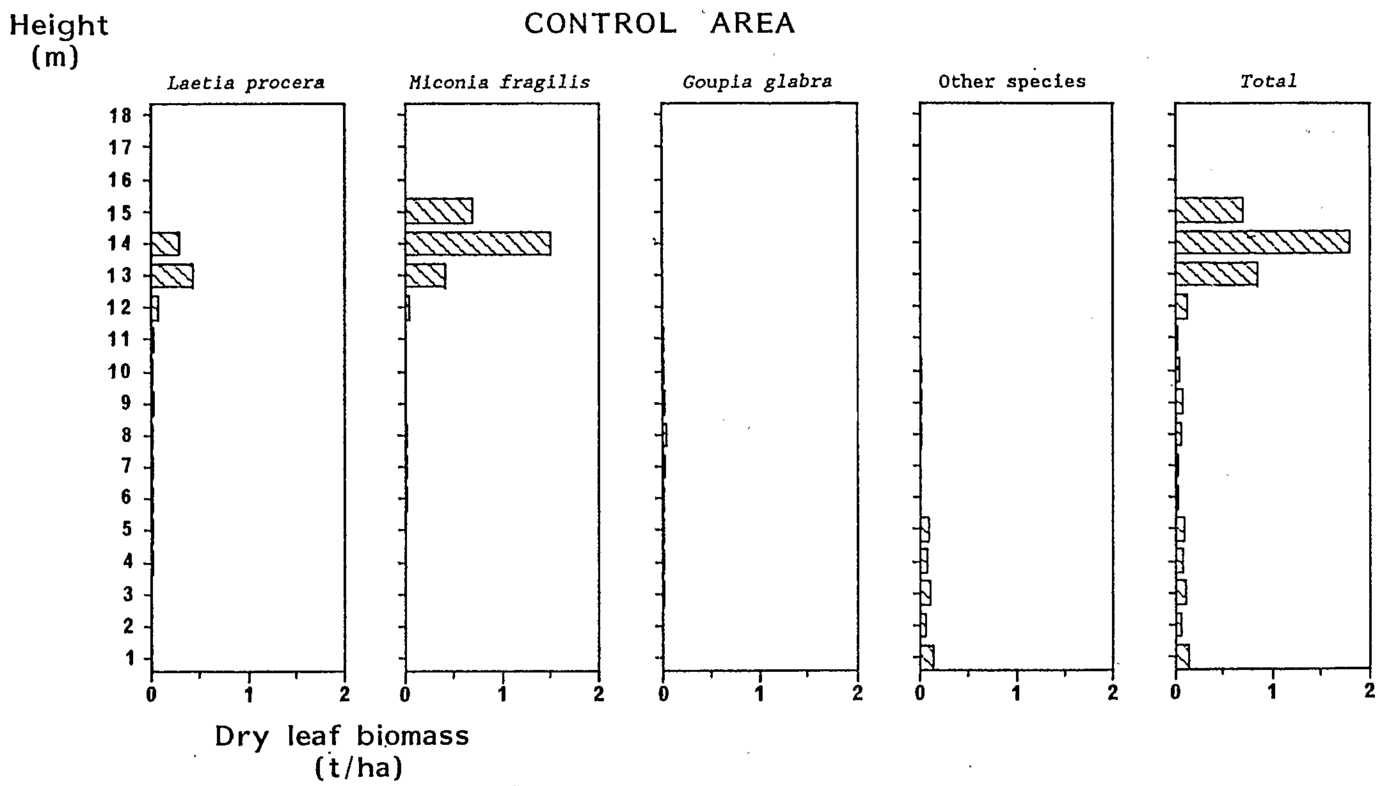

Figure 6b. Vertical leaf biomass distribution in control area.

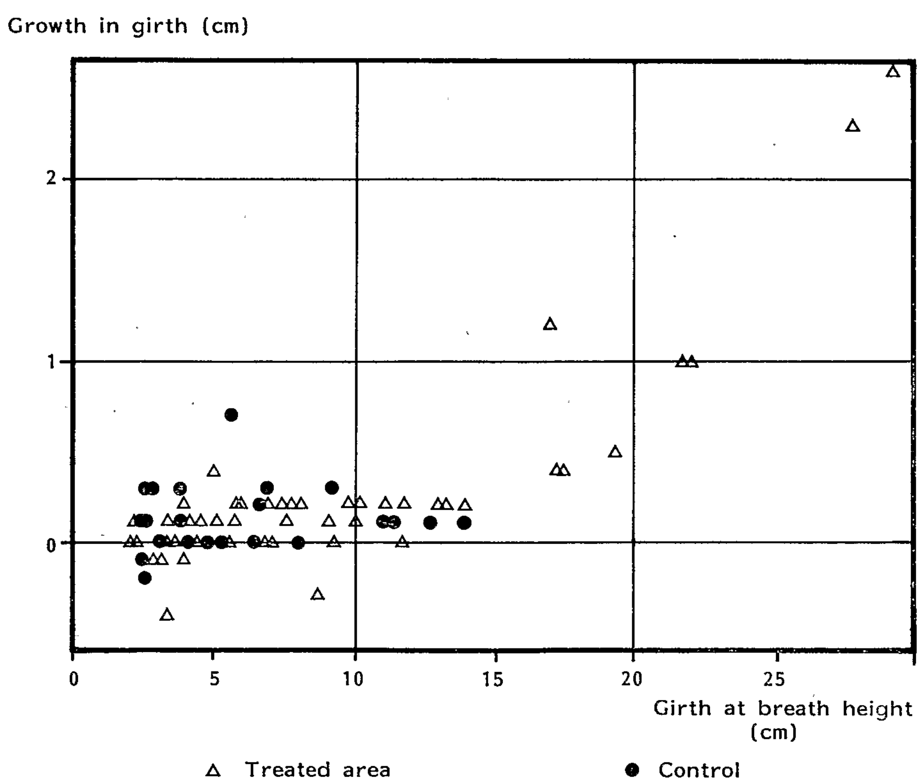

Figure 7. Growth of Goupia from April 14th 1986 to December 10th 1986, 3,5 years over forest management.

co-occurring species. Removal of some of the fast growing species, on the other hand, led to significant increases in the number and size of individuals of *G. glabra*. Timing of competitors removal might be of great importance, too early removal of fast growing trees would favor development of weedy, herbaceous species, while too late removal would be more time consuming and may result in reduced vigor of saplings of the useful species. In the present experiment removal of other locally abundant species such as *M. gracilis* might have promoted further development of *G. glabra*.

We suggest that these results are valid for other tropical wet forests. Further experimentation in this direction may prove to be appropriate for development of cost efficient management of succession and establishment of secondary forests enriched in economically useful speices.

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