CENTRE FOR AGRICULTURAL RESEARCH IN SURINAME

HUMAN INTERFERENCE IN THE TROPICAL RAINFOREST ECOSYSTEM

Project LH/UvS 01

MAB-PROJECT No. 949

ANNUAL REPORT

1983

ANTON DE KOM UNIVERSITY OF SURINAME

1983

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HUMAN INTERFERENCE IN THE TROPICAL RAINFOREST ECOSYSTEM

ANNUAL REPORT FOR 1983

1 INTRODUCTION

1.1 Objectives

The project sub-title reads: An evaluation of the consequences of interference on the potential productivity of the ecosystem, on its environment and on its capacity for sustained timber production.

The research objectives are designed to provide the knowledge upon which long-term land-use decisions can be based. Specifically, they include:

- the analysis of the effects of management and other practices on the rainforest ecosystem;
- the investigation of ecological processes, particularly those relating to production and to effects on neighbouring systems;
- the development of principles on which to base the planned management of the tropical rainforest.

In setting these objectives, a number of considerations apply. Some of these are:

- the paucity of quantitative knowledge about ecological processes in the tropical rainforest, particularly those relating to potential productivity;
- the knowledge that massive interference elsewhere in the tropics (and indeed locally in Suriname) has led to an irreversible decline in productivity;
- the fact that the tropical rainforest resource, covering 90% of the land surface of Suriname, must be developed rationally and conservatively as a national asset.

1.2 Research organization and background

Since the foundation of the Centre for Agricultural Research in Suriname (Centrum voor Landbouwkundig Onderzoek in Suriname, CELOS) in 1965, the Suriname Forest Service (Dienst 's Landsbosbeheer, LBB) has, as a matter of policy, concentrated its research to problems directly related to forest management, which could be solved in a relatively short time. The CELOS directed, in concert with LBB, its efforts on more fundamental research with long-term objectives, which include, but are broader than, forest management for timber production.

After the independence of Suriname in 1975, the University of Suriname (UvS) and the Agricultural University of Wageningen, the Netherlands (LHW) set up a small group of semi-autonomous research projects, based on CELOS. The first of these LH/UvS projects and the subject of this report is the forestry project 'Human Interference in the Tropical Rainforest Ecosystem'. This project has the task of investigating the whole spectrum of the ecological constraints on forest land management decisions and is, as such, the continuation of the CELOS-research executed between 1965 and 1975. The consultation and co-operation with LBB was continued too. The project is carried out in co-operation with another LH/UvS-project interested in land management. This LH/UvS-02 project has the objective of developing farming systems on the soils of the Zanderij formation based on non-irrigated annual crops.

1.3 Duration

The project was started in 1978 for a period of three years. In spring 1981 the University of Suriname and the Agricultural University of Wageningen agreed to continue the project till December 1983. Due to the long life cycle of trees, of forest and also of forest research, a continuation of the project after 1983 is necessary. Political developments in 1982 and 1983, however, prevented the opening of negotiations between the UvS and the LHW for a continuation of the project. Thus, against the hopes of all directly involved, the project was terminated on December 31st, 1983. Exceptionally, the forest exploitation research will be continued till July 1984.

In 1984, a number of scientific reports based upon the experiments of the project will be prepared by the responsible scientists at the involved Departments of the Agricultural University of Wageningen.

1.4 Acknowledgements

The assistance of many governmental and non-governmental institutions and agencies has been essential to the progress of the project in 1983. Especially mentioned should be:

- Forest research section of the Suriname Forest Service, for its assistance in the forest exploitation research.
- Bruynzeel Suriname Wood Company, for the assistance in the forest exploitation research.
- Soil Survey Department for assistance by preparing soil maps of the succession plots.
- Computer Centre of the University for putting its S34-computer at the disposal of the project.
- MAB-UNESCO, for financing the appointment of a labourer for nine months, the purchase of several scientific books and the participation of Dr. P. Schmidt in the International Symposium on Amazonia, held on 7-13 July 1983 at Belem (Brazil).
- Paramaribo Fire Department for the use of a nozzle and hoses.

The CELOS proved again to be an adequate home-base for the project. The scientific, technical and labour staff and the students, working in the forest and in the office, did not fail in keeping up the high quality, necessary for this work.

It is, as in previous years, the pleasant duty of the project leader to thank them all.

2 NON-RESEARCH MATTERS

2.1 Staff

In the year under review, the scientific staff was enlarged by a data processing specialist. Hence, at the end of 1983 the scientific staff of the project consisted of seven research officers and one field officer (see appendix 1). The two soil scientists were shared with the agricultural project.

During 1983 about 28 labourers were attached to the project, 22 of them paid by the project, one by MAB-UNESCO and four till five by CELOS. At the termination of the project the labourers paid by the project and by MAB-UNESCO were engaged by the UvS.

2.2 Consultants

From May, 3rd till 17th, Dr. P. Ketner (Agricultural University of Wageningen, Department of Vegetation Science, Plant Ecology and Weed Science) visited the project. The main purpose of his visit was the project research on secondary succession and on production ecology, but the research of the other disciplines of the project and the continuation of the project were discussed as well. All the successional plots and the main ecological plots were visited. The possibilities for further experiments in the second half of 1983 were screened.

2.3 Students

Due to the political developments in Suriname and in the Netherlands, the partial closure of the University of Suriname and the termination of the project on December 31st, 1983, only eleven post-graduate students from various universities and one student from a vocational school participated in the project research (see appendix 1). For these students seven excursions were organized (see appendix 2).

2.4 Visitors

The project received visitors from Suriname, the United States of America, French Guyana and the Netherlands (see appendix 2).

2.5 Visits to other countries

Due to the termination of the project and the added amount of work caused by it, only two visits to other countries were made (see appendix 2). In spring two members of the staff participated in the "Colloque ECEREX" in Cayenne (French Guyana) and in summer two members (one at the invitation of the organizing committee and funded by MAB-UNCESCO, as is thankfully acknowledged here) participated in the "International Symposium on Amazonia" in Belem (Brazil). At both symposia a lecture was given (see appendix 4).

2.6 Advisory work and liaison

The close co-operation with the Suriname Forest Service was continued.

2.7 Research planning

In the first half of the year under review the research of the project proceeded along the lines given in the masterplan for 1981-1983 (see appendix 3 of the annual report for 1980). In the second half the termination of the project caused deviations. Measurements planned for 1984 or later as a sequel of previous measurements were advanced, other measurements, building the starting point of a new series, were striked. Some series of measurements had to be broken off years too early. Moreover, much attention, time and energy was given to the careful labelling of all the experimental trees on those experimental plots of which a sequel survey before about 1990 is significant.

During 1983 twelve new experiments, spread over the six disciplines of the project, were started. A list of the existing experiments of the project at the end of 1983, also at the termination of the project, is given in appendix 3.

2.8 Data-processing

The data-processing of the project was mainly carried out on the S34-computer belonging to the Computer Centre of the University (URC). In the second half of 1983 much emphasis was laid on the editing and organization of the data-banks of the project and on the preparation for the change-over to the DEC-10 computer of the Agricultural University of Wageningen.

2.9 Infrastructure

Research Areas

The project had at the end of 1983 51 experiments (see appendix 3). The twelve new experiments were all but one established on the already existing locations (see fig. 1, 2 and 3 of the Annual Report for 1982). One experiment was established in Patamacca, the timber concession of Bruynzeel Suriname Wood Company, south-east of Moengo.

Due to the termination of the project, much attention was given to the protection of the experimental plots in the coming years. All the experimental trees were marked with aluminium-labels. In CELOS-rapporten 137 the location of the plots and the marking of the trees are described.

Forest Camps

The forest camps in Mapane and Kabo/Tonka were kept in shape.

Transport

No changes were made in the vehicle fleet of the project.

2.10 Publications, lectures

In 1983 twenty-nine publications based upon the project research appeared. Ten of those were student reports, three were papers read on international symposia. Besides in November 1983 a symposium with nine papers read by the scientific staff of the project was organized. Detailed information is given in appendix 4.

3 RECORD OF RESEARCH

3.1 General

Comparison of the project title and objectives with the allocated resources, particularly of scientific manpower, immediately makes it clear, that, firstly, many areas of work proposed in the original Project Protocol cannot be tackled, and, secondly, the research programme must be organized as an integrated whole and carried out in the most efficient way possible.

In preparing the overall research plan for the project, the work was broken down by disciplines and within those disciplines, by priorities. This enabled the individual scientists to identify their particular area of responsibility within the framework of the overall project objectives.

The experimental programme is designed to identify and explore the factors of productivity at points on the continuum from unexploited forest on the one hand to forest cleared for intensive silvicultural (or ultimately agricultural) use on the other. The main foci of the research programme are:

1. The response of the forest to logging and management, including:
   - silviculture: the exploration of the relationships between competition and regeneration, recruitment and volume production
   - the development of silvicultural management systems based on the principle of sustained yield
   - ecological monitoring (as in 4 below).
2. The response of the soil to forest exploitation or clearing followed by reafforestation, including:
   - fertility
   - structure and water-holding capacity.
3. The behaviour of small stream catchments under forest or other forms of land use.

4. The ecology of unexploited forest, including:
   - structure
   - phytomass
   - primary production and mineral cycling
   - floristics
   - forest dynamics (variation in space and time).

Due to the enlargement of the scientific staff in 1981 two other main points out of the project protocol could be inserted in the actual research plan:

5. The floristic and ecological aspects of the natural development of the vegetation after (clear-)cutting for different forms of land use.

6. Harvesting systems, including:
   - the assessment of the damage caused by the harvest on the forest, the forest soil and on the possibilities for natural regeneration
   - the development of harvesting systems causing a minimal amount of damage.

Many of these areas are multi-disciplinary and experiment plans are frequently worked out by two or more scientists in collaboration. The whole team has the opportunity to discuss and contribute to each experiment plan.

3.2 Silviculture

Since the late fifties, attempts have been made to establish a silvicultural system for the Suriname rainforest based on natural regeneration. CELOS has been involved in this kind of research since 1965. A large number of different treatment schedules was tried in the relatively small-scale experiments Expt. 65/3 (est. 1965) and Expt. 67/9A (est. 1967). The effect of logging on forest growth was recorded in Expt. 67/9A and in two 5 ha trials (Expt. 67/2A and B, est. 1967). Results published by DE GRAAF and GEERTS in 1976 in CELOS rapporten 114 pointed towards a polycyclic rather than a monocyclic system. The silvicultural technique proposed by them includes poison-girdling of all non-commercial trees above a diameter limit of approximately 20 cm and liana cutting. This initial refinement, which is carried out approximately one year after logging, has to be followed by a second and a third refinement after approximately 8 and 16 years.

In 1975, a 25-ha trial (Expt. 67/9B) was established in order to try this treatment schedule. Although it produces useful information this trial is not fit for statistical testing methods. Therefore, a large-scale experiment (Expt. 78/5, 140 ha) was initiated in 1979. Three silvicultural treatments and three logging intensities are applied in a factorial set-up with three replicates. The development of the commercial species as well as other components of the vegetation is assessed in this experiment. The main purpose of Expt. 78/5 is to test the effects of logging and silvicultural treatment on the growth of commercial species. However, it is expected to yield other information of silvicultural and ecological importance as well.

Furthermore, the silvicultural research programme includes an arboricide trial (Expt. 81/36), a pilot study on the relation between vegetation and soil (Expt. 82/15) and a simulation of the effects of various silvicultural treatments on the commercial stand (Expt. 83/1).

3.2.1 The older experiments (established before 1978)

None of the older experiments was enumerated in 1983. A soil survey was carried out in Expt. 67/9A and B and some data on the soils of Expt. 67/2A and B were collected.

3.2.2 The large-scale experiment 78/5

3.2.2.1 Progress

Like in previous years, experiment 78/5 received more attention than all other silvicultural experiments combined. The annual enumeration which started in November 1982, was completed. Besides the usual parameters, the stem volumes of commercial trees and the exact locations of all stems in the one-hectare plots were assessed. The virgin jungle plots were included in the enumeration. One-hectare plots were established in the virgin jungle plots for this purpose.

From August 1982 until September 1983 monthly phenological observations were made in replication II in plot 1 (moderately heavy logging, most intensive silvicultural treatment) and plot 2 (heavy logging, no silvicultural treatment).

Furthermore, field work for a soil map and a contour map was carried out. Unfortunately the soil survey could only be completed partly before the termination of the project. No soil data are available of the SE part of replication II.

Much attention had to be paid to data processing. The data from the latest enumeration were stored on a computer disk. It appeared that the edited versions of the computer files of previous enumerations had disappeared which means that the time consuming data editing procedure had to be done all over again. At the time of writing, all the files are virtually free from detectable errors. Very little time could be spent on the analysis of the data of this experiment. Some results of the phenological observations are discussed below.

3.2.2.2 Phenological observations

The phenological observations were carried out on all trees of at least 15 cm dbh in two 0.25 ha blocks which are used also for the primary production and nutrient cycling studies (see section 3.5.2). Plot 1 received a poison-girdling treatment 9 months before the observations started, plot 2 has not been treated. Both plots have been logged selectively in 1980.

Ninety-seven trees, 48 in plot 1 and 49 in plot 2, are included in the analysis. Most of these belonged to a commercial species (28 individuals in each plot). By far the most common species was Qualea rosea (a commercial species, 16 trees in plot 1, 13 trees in plot 2). Other rather common species are Dicorynia guianensis (a commercial species, 3 trees in plot 1 and 5 trees in plot 2) and Minquartia guianensis (a non-commercial species, 3 trees in each plot). The remaining 54 trees belong to as many as 40 different species, of which thirty species are present in just one of the two plots.

Observations were made on flushing, flowering and fruiting. The results suggest a positive response of the commercial species in general and Qualea rosea in particular to the poison-girdling treatment.

Q. rosea trees flushed and flowered more abundantly and over longer periods in the treated forest. They produced more fruits as well.

The results for all commercial species combined are self-explanatory. New leaves were recorded 171 times in the treated plot 1 against 137 times in plot 2. Flowering was observed 24 times in plot 1 and 16 times in plot 2 and fruiting was seen 57 times in plot 1 and 43 times in plot 2.

The non-commercial species behaved quite differently. The larger trees had been poison-girdled in plot 1, leaving only the phenologically less active smaller individuals. Hence, non-commercial species were seen flushing, flowering and fruiting more often in plot 2 than in plot 1. New leaves were seen 83 times in plot 1 and 125 times in plot 2. Flowering was observed just 6 times in plot 1 and 13 times in plot 2 and fruiting was recorded 6 times in plot 1 and 23 times in plot 2.

3.2.3 Recent experiments (established since 1980)

3.2.3.1. The arboricide trial (Expt. 81/36)

The arboricide trial was established in October 1981. Its main purpose is to reduce the amount of arboricide used in the silvicultural treatment.

Five different poison-girdling techniques were applied in parallel strips of 100 m wide. The experiment has no replications. One of the treatments (treatment V) is similar to treatment SR 14 in Expt. 78/5. Unwanted trees of a diameter of 20 cm or more were frill-girdled and poisoned with a 5% solution of 2,4,5-T in diesel oil. The poison was administered in two steps. First the frill was filled and afterwards the bark directly above the frill was covered with a film of the solution over a height of about 10 cm. Treatment IV is similar to treatment V, except that the arboricide is poured into the frill only and not upon the bark above it. Treatments II and III are similar to treatments IV and V respectively, except that the concentration of 2,4,5-T is 2½% instead of 5%. In treatment I it was tried to kill unwanted trees without poison by ringing them twice. Most trees with buttresses and irregularly shaped stems could not be treated this way and were poison-girdled according to the prescriptions of treatment III.

The experiment was enumerated twice in 1983, once in January (see also LEEFLANG, 1983, internal report) and once in October. The trees to be eliminated (100 per treatment) were classified into five categories, viz. dead or bare (cat. 1), almost bare (cat. 2), phloem transport interrupted over the whole circumference of the tree (cat. 3), phloem transport interrupted over almost the whole circumference of the tree (cat. 4) and recovered (cat. 5).

The results from the latest enumeration, which are summarized in table 1, are very encouraging. The results of treatments I, II and III suggests that the 2,4,5-T concentration can be reduced from 5% to 2½% or even less.

Table 1. Effects of the treatments applied in Expt. 81/36. Percentages of the number of treated trees, 2 years after refinement.

Category	Treatment[1]					
	Ia	Ib	II	III	IV	V
1 (dead/bare)	49%	91%	81%	84%	52%	75%
2 (almost bare)	23%	2%	4%	6%	14%	9%
3 (no phloem contact)	28%	4%	5%	4%	6%	7%
4 (some phloem contact)	-	2%	10%	5%	27%	9%
5 (restored)	-	-	-	-	1%	-
not found	-	-	-	1%	-	-
Total	100%	99%	100%	100%	100%	100%

1) For explanation of codes: see text. Ia refers to the 53 trees which were ringed twice, Ib to the 47 trees poisoned in treatment I.

The poor results of treatment IV are probably caused by human inaccuracy, i.e. arboricide was not always administered over the whole circumference of the tree. This is a likely mistake for a tired person to make. The arboricide which has been poured into the frill is soaked up rapidly by the tree, i.e. it is not possible to see which part of the frill has been treated already. In order to avoid this risk, the arboricide should be applied on the bark as well.

The attempt to kill trees by ringing them twice did not prove to be successful yet, although the mortality of the double-ringed trees is still increasing steadily (from 32% in January to 49% in October).

Summarizing, the results from this experiment suggest that a 2½% concentration of 2,4,5-T in diesel oil is sufficient and that the solution should be applied both in the frill and on the bark directly above it.

3.2.3.2 Relation soil and vegetation (Expt. 82/15).

The pilot study on the relation between soil and vegetation was carried out in a 600 m long and 20 m wide transect (VAN LEEUWEN, under preparation, internal report). This transect is located within the hydrological experiment 78/34 and runs more or less perpendicular to the contour lines.

The soils in the transect were analysed first. Five soil types were recognized, viz. a well drained Ultic Haplorthox near the water devide, a moderately well to somewhat imperfectly drained Plintic Paleudult on the western slope, an imperfectly to poorly drained Aquic Quartzipsamment on the lower slopes near the valley bottom, a very poorly drained Histic Tropaquept in the valley itself and a somewhat imperfectly drained Orthoxic Quartzipsamment on the eastern slope.

Secondly, the forest was studied, using profile diagrams à la Oldeman. These profile diagrams were analyzed with emphasis on forest structure. This resulted in eight different forest stands, five of which were more or less mature undisturbed forest. A phytosociological analysis of the undergrowth according to the principles of the Zürich-Montpellier school supported this subdivision.

Thirdly, the location of the soil types and the forest stands were compared. It appeared that these matched very well. A well developed forest with emerging trees (mainly Qualea rosea) was growing on the Ultic Haplorthox. A dense forest with the palm Astrocaryum sciophilum dominating the understorey was found on the Phlintic Paleudult. The Aquic Quartzipsamment carried a thin stemmed Eperua falcata forest and a dense forest with a large number of treelets (e.g. Heisteria cauliflora) in the understorey was present on the Orthoxic Quartzipsamment. The vegetation of the swampy valley bottom was strikingly different from the other stands with characteristic species like Pterocarpus officinalis with its elongated buttresses and the palm Euterpe oleracea.

W.J.

3.3 Soil fertility

3.3.1 The pine experiments

When circumstances forced us to end the fertilizer experiment on pine, harvesting and analysis of samples from a number of trees provided some information on the phytomass and nutrients present in the 5 year old trees. The results were compared with the amount of phytomass and nutrients in the soil, the fertilizers applied and the original forest (see annual report for 1982).

The wish to make the same kind of comparisons in the older pine plantations nearby, where the amount of nutrients in the phytomass can be expected to be of greater importance than in the fertilizer experiment, and the lack of applicable information obtained elsewhere made us decide to harvest and analyse also some pine trees in plantations established in 1966 and 1969. The first was planted directly after clearing in 1966 and the second after 3 years of unsuccesfull eucalypt following clearing.

In the two plantations tree diameters were measured and 19 trees, - well spread over the various diameters classes - were harvested for the determination of dry weight and nutrient content in needles, branches and stems.

By the end of the year, when the project withdrew from Suriname, not all the information had become available yet. Still, rough estimations can be given (table 2) borrowing figures for nutrient contents from pine in the fertilizer experiment and the ratio for roots over above-ground phytomass from the forest near Kabo.

Table 2. Amounts of nutrients (kg/ha) in soil and phytomass of pine plantations and the nearby original forest (TRF).

nutrient	in soil (0-120 cm)*			in phytomass		
	pinus'69	pinus'66	TRF	pinus'69	pinus'66	TRF
N	3.167	3.128	3.818	390	1.027	1.113
P	30	40	28	41	112	64
K	115	118	102	108	261	720
Ca	489	494	547	138	365	1.574
Mg	86	222	263	53	143	152

* Extraction methods for agricultural purposes.

For the adjacent tropical rainforest on the same soil, used for comparison, nutrient contents in the phytomass have been calculated from the tree diameters measured and data borrowed from the forest near Kabo, including the following three equations (see Annual Report for 1980):

1. $\log L = -3,764 + 1,996 \log D$
2. $\log B = -4,852 + 2,837 \log D$
3. $\log S = -3,485 + 2,513 \log D$

(Dry weight in kg of L = leaves, B = branches, S = stems and D = diameter in mm)

The figures for nutrient contents of the soil have been obtained from the analysis of samples from three profile pits, one in each of the three plots, and a number of augerings. They are regarded as insufficient and eventually have to be replaced by figures from samples collected more intensively at the end of the year.

From the provisional data the following conclusions can be drawn:

1. the local tropical rainforest is less vigorous than the forest near Kabo (only 24 trees/ha had a diameter of more than 40 cm) notwithstanding the fact that the loamy sand involved proved to be "richer" than the heavier soils near Kabo. This is probably caused by the light exploitation before 1966.

2. The amounts of N and P do not seem to be lower in the oldest pine plantation than in the original forest. Some N was lost from the soil after clearing.
3. The amount of K in the oldest plantation is much lower than in the original forest. Combination with the low levels of this element in the soil makes a remarkable loss obvious.
4. Ca in the phytomass shows the same losses as K, however in combination with a Ca level in the soil that is much higher than at Kabo. The figures for Ca and Mg in the soil are such that it was decided to collect some more soil samples for control. The results are not available yet.
5. The 1969 plantation is much further behind on the 1966 plantation than can be explained by the 3 years difference in age. During the first 3 years after clearing much of the fertility from the original forest must have vanished and left the soil infertile for the plantation which started after eucalypt with a 3 year delay.

During the work it was found that - apart from the lack of information on the phytomasses involved and the subsequent use of assumptions based on data obtained elsewhere - a number of other factors must have adversely affected the reliability of results. Most obvious was the following:

1. Nutrient contents in the soil are very low in general and make small but significant changes difficult to be analysed.
2. Soil homogeneity under natural forest is small and clearing procedures do not improve the situation at all. This makes it difficult to collect representative soil samples in places where it is not clear what exactly happened in the past.
3. For reasons of accessability, most plantations of different ages are separated by broad paths, along which samples cannot be collected because of the influence of border effects and former windrows. Specially in the adjacent original forest the border to be avoided is rather wide (40-50 m) due to the fact that trees have been pushed over into the forest during clearing. For this reason soil samples were often obtained from places rather far apart while old soil maps, if available, show insufficient details to indicate whether the soils involved were originally the same.

4. During clearing obvious changes in terrain must have been used to determine the limits of the area to be planted with pine. As a result many boundaries of the plantations tend to coincide broadly with original changes in soil properties such as sandiness and water regime.
5. The original forest alongside the plantations in most cases has been lightly exploited and therefore cannot be regarded as untouched.
6. Loss of some topsoil into the windrows and compaction of the soil during clearing introduces differences in sampling depths for soils with different histories when sampling is done in the usual way. These differences can hardly be avoided.

In an attempt to broaden the basis on which to compare soils under different management regimes, during the last months of this year soil samples were collected at several other places where the original forest meets cleared land.

O.B.

3.3.2 Fertilizer experiments in natural forests

Two fertilizer experiments in natural forest are conducted. In December 1979 the first experiment was started at Mapane in silviculturally treated forest on residual soil (well drained sandy clay on clay) and in March 1982 the second experiment was started at Kabo in undisturbed forest on sedimentary soil (well drained sandy loam on sandy clay loam).

In both experiments fertilization took place at the start of the experiment and the growth of the forest and the soil fertility are followed from the start on a regular basis. In both experiments fertilization is compared against no fertilization.

The chemical fertilizers used in both experiments supply P, K, Ca, Mg, S and trace elements. N is not given. The fertilizers are triple superphosphate, potassium magnesium sulphate and "Fritted Trace Elements" with Zn, Mn, B, Fe, Cu and Mo.

The purpose of the experiments is to determine whether nutrient supply is a limiting factor in the growth of the forest.

The trees in both experiments were recorded in the beginning and at the end of 1983. In this year the soil and litter was sampled for chemical analysis. In 1984 no observations will be done, but all trees have been marked with aluminium labels so that in the future the observations can be continued.

R.L.P.

3.4 Hydrology

The hydrologic research is concentrated in Expt. 78/34: 'Water and nutrient flows in a forested creek catchment and the influence of logging and silvicultural treatment on the soil and the composition of the drain water'.

The experiment is a catchment, large 300 ha with two tributaries joining to form the main creek across which a dam with a discharge measurement structure has been placed. Continuous recording of rainfall and water discharge occurs. Weekly samples are taken from creek- and rainwater for chemical analysis. The catchment area of the western tributary was refined in 1981, whereby the basal area was reduced from about 28 to about 14 m^2/ha. The catchment area of the eastern tributary remained undisturbed. Changes in drainwater composition following refinement are studied to determine losses in fertility as a result of the treatment.

Four water samples are taken once a week. One from the overflow of the V-notch representing the drainage water of the whole catchment, one from the eastern tributary, representing the subcatchment with the undisturbed forest, one from the western tributary representing the catchment with the treated forest and one rainfall sample. In these samples the electrical conductivity is measured and the amounts of Ca, Mg, K, Na and P are determined.

Field work for a soil survey of the whole catchment area and the sampling of litter and soil was done in 1983. Water levels in 18 deep borings (7.50 m deep) were recorded weekly. Water samples from these deep borings were taken twice for chemical analyses and permeability test of the subsoil were done with the auger hole method.

Most observations were discontinued at the end of 1983. Analysis of the results and reporting is scheduled for 1984.

R.L.P.

3.5 Production ecology

The whole research programme of the project, and particularly the ecological research programme, is focussed on the question "How far can we manage, can we interfere, in the tropical rainforest without jeopardizing its capacity to renew itself and to maintain its biological productivity?" Most attention is given to the interference (viz. exploitation and refinement) as prescribed in the silvicultural system developed by DE GRAAF (see CELOS RAPPORTEN 114; Annual Report for 1978, 1980) which is thought to give a sustained timber yield. If this is true, the forest under this management system would contribute regularly and continuously to the economic development of Suriname.

The criteria used for the ecological appreciation of the proposed silvicultural system are the standing phytomass and the primary production, the mineral capital and the mineral cycling and, less important, the floristic composition.

3.5.1 Standing phytomass

In previous years the standing phytomass of the forest stands Fytomassabos (unexploited, at Kabo) and Proctersbos (lightly exploited, at Mapane) was already determined (see Annual Reports for 1980 and 1982). In the year under review, the chemical analysis of the samples collected in 1982 in the forest stands Akintosoela (lightly exploited and refined, at Mapane) and Weyerhäuser (heavily exploited, at Mapane) could be concluded. A first processing of the data was carried out. The results will be published in the final report on the ecological research of the project.

In these four experiments it was attempted to estimate the rootmass under these forests too. Therefore, the rootmass of 41 small pits, spread over the four forest stands, was dried and weighted. In the

Fytomassabos 65.2 ± 13.1 (standard error) ton/ha of roots was found, in Proctersbos only 25.7 ± 4.7 ton/ ha, in Akintosoela 55.3 ± 41.5 ton/ha and in Weyerhäuser 24.2 ± 10.5 ton/ha.

These soil pits of 50 x 50 x 50 cm each were considered as too small. It was decided to examine at least on one location the root-mass under a larger area, if possible under a 10 x 10 m plot, the size of the 41 phytomass-plots. Out of the various techniques available, the water-jet-method was chosen as conscientious enough and quicker and for the labourers easier and more enjoyable than digging and sieving.

In February in Procterbos in Mapane a plot of 10 x 10 m was found, fulfilling the ecological, experimental and technical conditions, viz. a piece of high dryland forest with many tree species and a diameter distribution with possibilities for correlation calculation, on a soil covering about 15% of the area, near enough to an abundant water source (creek), on a slight slope, with possibilities for the deposition of about 100 m^3 removed soil, without evidence of a (permanent) ground-water level within 2.25 m below surface and without evidence of human interference. The basal area was 1.15 m^2 on 100 m^2, which is high but not close to the maximum. The largest tree on the plot was a Sclerolobium micropetalum with a diameter of 99 cm and a height of 48 m.

In April the preparations (viz. profile drawing and soil description) were finished and in May the harvest and measurements of the phytomass above ground followed. Between May 24th and December 8th, with an interruption of 3½ months, the soil was washed away and the roots collected. As much as possible, whole root systems were collected, but small roots (below about 3 mm diameter) were ripped of by the water-jet and thus sampled as bulk material. Roots between 3 and 10 mm slowed down the waterflow in such way that soil particles were deposited too early. These roots had to be collected and treated as bulk material too. This experiment was terminated on December 8th, when a mean depth of 93 cm below surface had been reached.

The result of this experiment will be discussed in the final report on the ecological research of the project. A map of a part of the root system of tree 7 (Eschweilera poiteaui) is given in fig. 1.

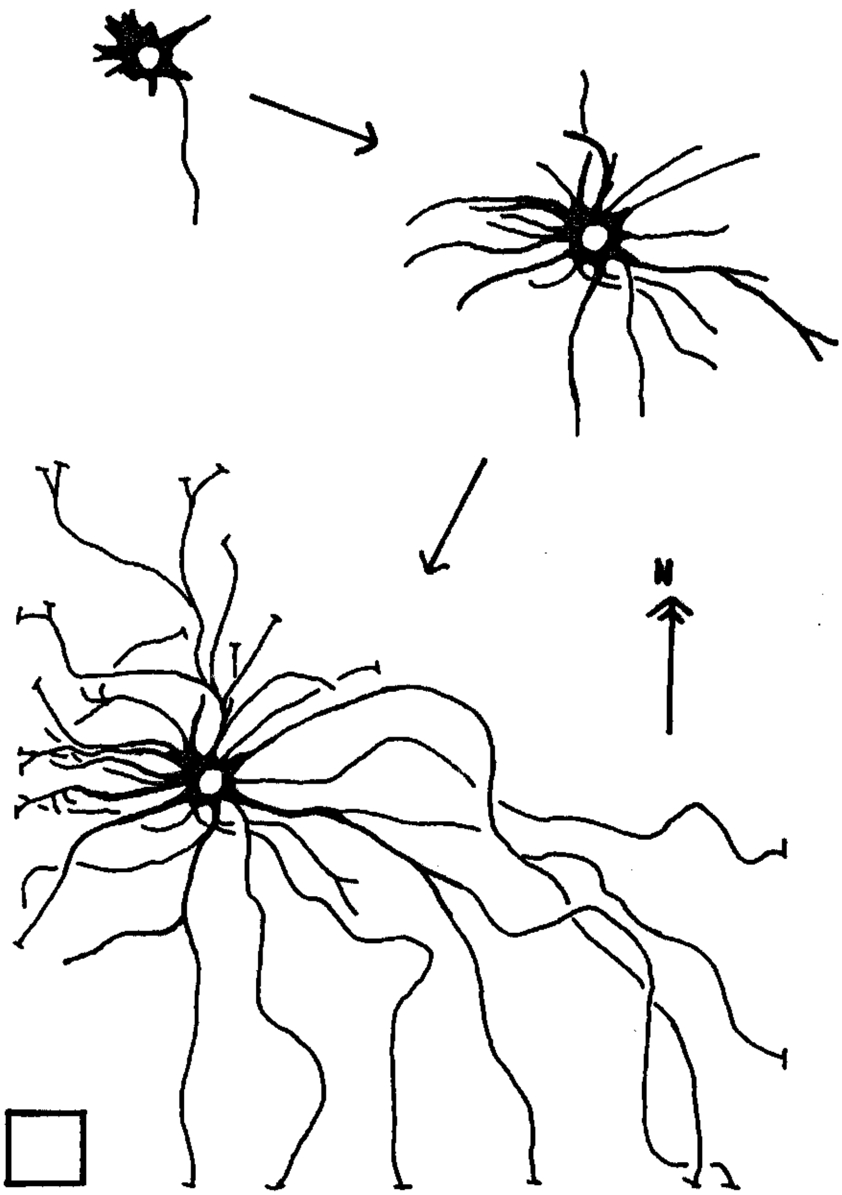

Fig. 1: Root system of a Eschweilera poiteaui (height 32 m, d.b.h. 45-50 cm, rootmass in the plot about 200 kg dry weight) between 0-20 cm (above, left) between 0-50 cm (above, right) and 0-93 cm (below). Location Proctersbos, Mapane. The square indicates an area of 1 m^2.

3.5.2 Primary production and nutrient cycling

The experiments for recording litter fall and primary production ran in their third year. In January one identical experiment in a lightly exploited forest stand in Kabo/Tonka was added to the six already running. Coinciding with the last measurements of the girth of the trees, the last counting of the palm leaves and the last sampling of fallen trees, the recording of the litter-fall was terminated in October 1983. The results will be discussed in the final report. The trees belonging to these experiments were not labeled.

3.5.3 Litter decomposition

An important part of the nutrient cycle is the breakdown of litter. Before the surrounding vegetation can use the nutrients incorporated in dead leaves or wood, decomposition must occur. Many processes and many organisms are involved in the decomposition. In the frame work of the project only the overall proces of breakdown is investigated.

In 1983 biology-student VAN DER STEEGE and after his departure assistant ANDREAS ORASSIE continued the experiments concerning the breakdown of litter till the end of November 1983. Not all the data are available yet, but those already interpreted corroborate the slow breakdown rate mentioned in the Annual Report for 1982.

P.S.

3.6 Vegetation ecology

3.6.1 Introduction

Succession may be studied either by direct or by indirect methods. The vegetation studies at CELOS are mainly focussed on the direct method, which means a periodic recording of the vegetation in permanent plots during a certain length of time. Thus, changes in botanical composition and structure are followed closely, giving a detailed picture of succession in the plots studied.

In 1967 CELOS started succession studies in the lowland rainforest (in the sense of Richards) of Suriname. Different sized permanent plots were laid out in various vegetation types, originating from virgin forest after some form of human interference. The succession was followed on deforested areas, in exploited forest and on land abandoned after shifting cultivation.

3.6.2 Methodology

As in previous years the vegetations of the different succession plots were described on the basis of floristic and structural characteristics and the measurements of the girth at breast height (gbh). Profile diagrams were drawn following the Oldeman method and relevés were made using a modified Braun-Blanquet method. Recordings of standing phytomass, light intensities and shoot growth were continued (for details see Annual Report for 1982). In the year under review a soil survey was carried out with the assistance of the Department of Soil Survey (DBK) of the Ministry of Natural Resources and Energy in Suriname.

The exact location of the succession plots including the transects is described in CELOS RAPPORTEN 137.

3.6.3 Progress and some preliminary results

3.6.3.1 Succession on a cleared area

Relevés were made in all the succession plots and in Tonka, Sarwa Houtskool and Weyerhäuser an floristic inventory was carried out. In the last mentioned plot a striking number of Pourouma sp. seedlings led to a count in a number of subplots.

In Blakawatra the mortality of trees ≧ 100 mm gbh was recorded. Height and girth measurements were repeated in Sarwa Houtskool.

In Coesewijne Houtskool the location of an old skid trail network was mapped, together with the remaining dead wood left after the charcoal exploitation.

3.6.3.2 Succession after shifting cultivation

Within the frame work of the study of secondary succession emphasis is also placed upon natural regrowth on land abandoned after agricultural use. Such pieces of land, which are locally called "kostgrondjes", can be found in the surroundings of either permanent or temporary settlements in the interior. According to the terrain conditions, the history and probably also the features of the surrounding vegetation, there might develop different types of secondary vegetation. It is the aim of this study to distinguish these different types in relation to the environment.

In 1970 three plots of each 20 x 50 m and one plot of 10 x 10 m were staked out in the surroundings of the Amerindian settlement Bigi Poika which lies in a transition zone between a mesomorph evergreen seasonal forest and a savannah forest. At this moment the age of the vegetation in the different plots varied from 40-50 years. The last recording of girth measurements took place in 1974. In 1983 the succession study was resumed. At first a tour of inspection was made. Most of the pickets were gone so it was quite hard to recognize the exact location. The markings of the plots were renewed and a new map has been drawn. Girth measurements $\geqq$ 100 mm gbh were recorded in the different plots. Relevés were made in 16 subplots.

3.6.3.3 Phytomass and mineral content

Several plots, in Sarwadriesprong one, Coesewijne Houtskool one, Tonka three, and in Sarwa Houtskool two, were selected and harvested to measure the above ground phytomass.

3.6.3.4 Vegetation structure in relation with shoot growth and light intensity

In the various succession plots one or two transects of different lengths (depending on size and/or homogeneity of the vegetation) were chosen to do recordings of horizontal and vertical structure, shoot growth and light intensity.

Fig. 2: Profile diagram (above) and crown projections (below) of the undergrowth of a 14 years old secondary vegetation. Location Weyerhäuser, Mapane. For an explanation of the ciphers, see text, a list of species is given in table 3.

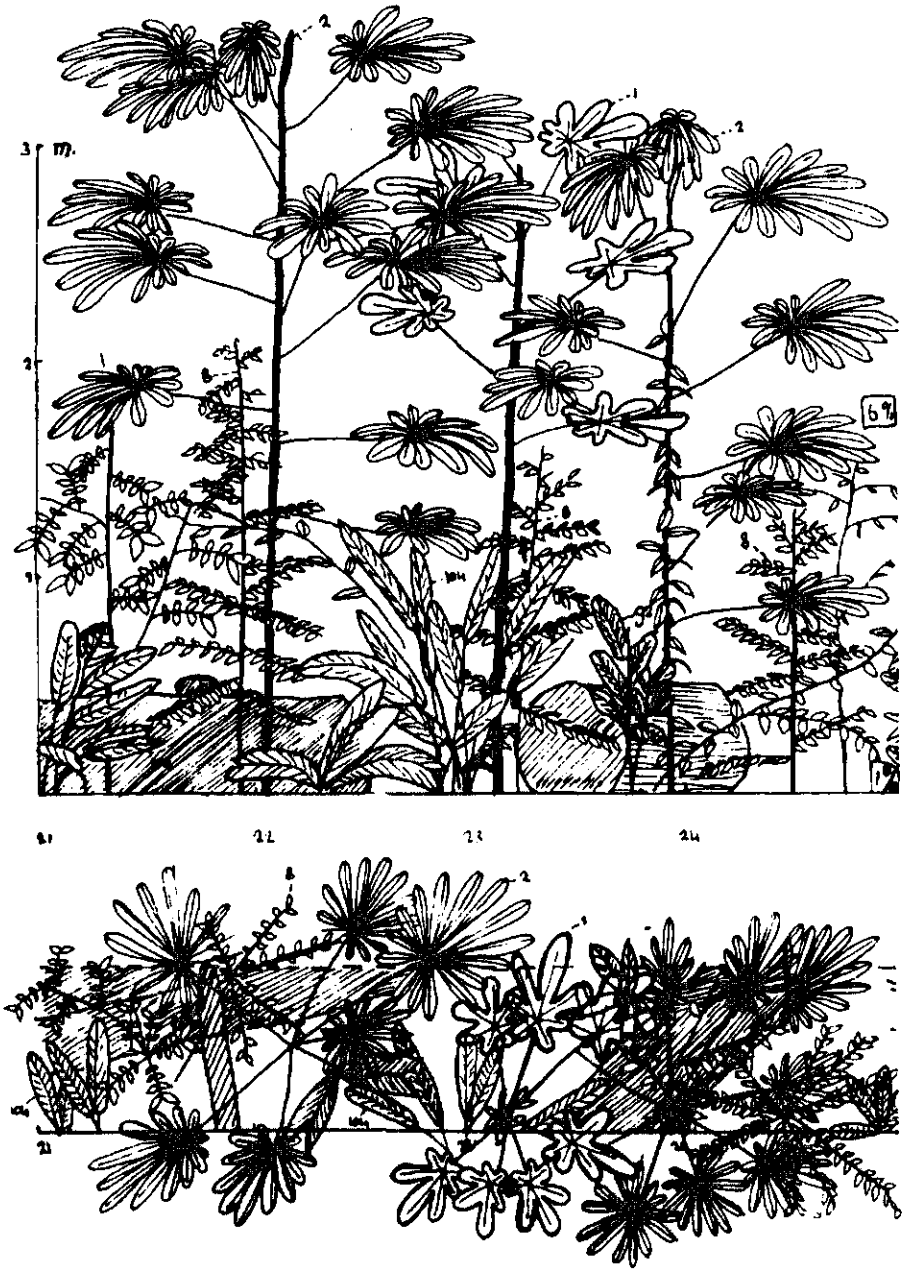

Fig. 3: Profile diagram (above) and crown projections (below) of a 15 months old secondary vegetation. Location Tonka, Kabo. For an explanation of the ciphers, see text, a list of species is given in table 3.

Table 3. List of species belonging to fig. 2 and 3.

Nr.	Botanical name	Family name
1	Cecropia obtusa	Moraceae
2	C. sciadophylla	Moraceae
3	Palicourea guianensis	Rubiaceae
8	Goupia glabra	Celastraceae
42	Pourouma mollis	Moraceae
44	Eschweilera odora	Lecythidaceae
49	Bonafousia undulata	Apocynaceae
75	Maximiliana maripa	Palmae
92	Solanum sp.	Solanaceae
97	Andropogon bicornis	Graminae
99	Scleria secans	Cyperaceae
101	Pityrogramma calomelamos	Pteridophyta
104	Heliconia sp.	Musaceae
106	Ischnosiphon gracilis	Marantaceae
122	Indet.	-
127	Symphonia globulifera	Guttiferae
128	Piper sp.	Piperaceae

Fig. 2 represents a profile diagram of the undergrowth of a 14 years old secondary vegetation. Fig. 3 is an illustration of a secondary vegetation 15 months after cutting and burning. The heights and the distances are recorded in meters; each species up till 3 m has a number, the numbers of the trees above 3 m height with a permanent aluminium tag, are placed in compartments. A list of species is given in table 3.

Fig. 4 shows that the mean growth rate is highly variable for the different succession plots. This of course depends on the structure, the light regime, the soil conditions, the history etc. of the stand. Nevertheless one can see that in general the apical meristemes grow faster than the branches and furthermore that the mean growth rate increases with height above surface. This means that at a height of 1.50 m plants grow faster at the top than at 0.20 m height, of course also depending on overshadowing from the layer above.

The growth rate at Tonka is striking, but the contribution of lianas in this young stage of succession (about two years old) accounts for this high growth rate.

According to the rate of growth of the branches, there is hardly any difference between the different recording points (0.20 and 1.50 m height).

The relationship between growth rate and light intensity is evidently. The more light, the higher the growth rate and this can also be seen in fig. 4. The phenomenon of overshadowing which is already mentioned, can be illustrated by comparing column 5 + 6 (Weyerhäuser) with 8 + 9 (Sarwa Houtskool). These two succession plots differ greatly in age and therefore in structure of the vegetation. There is hardly any difference between Weyerhäuser 0.20 and 1.50 m because they are both shaded by a fairly closed canopy, whereas in Sarwa Houtskool a canopy is lacking.

To gain more insight into the rate of growth one should also take into account some other parameters which together influence this, such as soil conditions, developmental stage of the vegetation, environmental factors, etc.

Being only a pilot study it is not easy to draw definite conclusions at this very moment. The data have to be analysed more accurately and there should be a follow-up to get more data. More details can be found in the M.Sc.-thesis prepared by H. HAGG and M. PEL.

3.6.3.5 Soil mapping

In the different succession plots borings were carried out every 10 or 25 m dependent on the homogeneity of the soil, up till a depth of 1.20 m and occasionally till 2.20 m. The soil description included mainly texture, colour, mottling and charcoal content. The analysis of these data is in preparation.

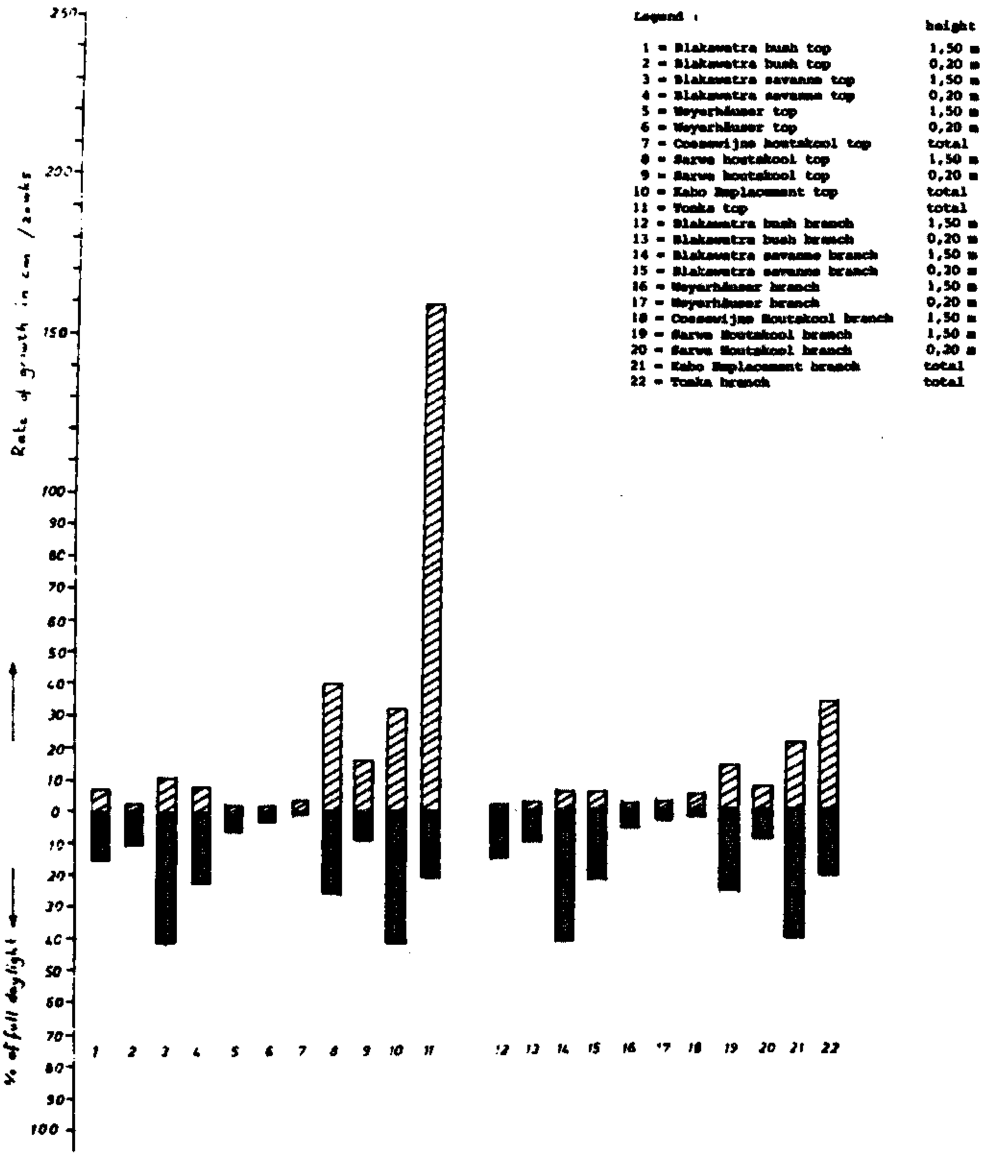

Fig. 4: Mean rate of growth in 20 weeks and the mean light intensity (as percentage of full day light) in different aged succession plots.

The influence of soil compaction on succession was studied by means of soil profile pits of 1 x 1 x 0.80 m. This study was done by biology students T. BOERBOOM, B. KRUYT and H.J. MÜLLER as part of their M.Sc.-thesis.

3.6.3.6 Influence of seed source distance on succession

To study the influence of seed source distance, seed was collected in 3 soil pits of 1 x 1 x 0.10 m^3 to do a viability test for both Kabo and Mapane. Seed supply from the surroundings into the succession plots was determinated by fitting up pieces of cheese cloth between poles in a 1 meter square. After 1 month the cloth was removed and the seeds were germinated in the greenhouses at CELOS. Biology students T. BOERBOOM, B. KRUYT and H.J. MÜLLER will publish first results in their M.Sc.-thesis.

R.T.L.S.

3.7 Harvesting systems

After the studies on traditional logging and its impact on harvesting damage, the research was gradually conducted to the development of systems with a higher productivity and a lower level of damage. Although there were no funds available for technical improvements and hence for a better choice of logging machines, some progress could be made by regulating felling and skidding and by experiments with available equipment. A study on careful log collection started late in 1982 (see Annual Report for 1982), the last field measurements were completed early in 1983.

Skidding damage is mainly determined by the applied logging system, by the type of machines in use and by the operator's skill. As so far only data of wheeled skidding were collected while information on an other important skidder, the crawler tractor, was not available. With the co-operation of Bruynzeel Suriname Wood Company, crawler skidding could be studied in a commercial operation.

The fieldwork of the harvesting research will be continued until June 1984 and the results will be published in the next few years. In this report only a brief description will be given of the two studies mentioned.

3.7.1 Winchlogging

A very effective way to reduce skidding damage is to winch logs from the stump to the skid trail instead of bringing the skidding machine into the forest near to the felled trees. A small experiment was executed by using the winch system of a caterpillar wheeled skidder to collect logs from a maximum distance of 30 meters. Although the machine was not specially equipped for this kind of work, it turned out that extraction by winch is technically possible in a rainforest in spite of dense undergrowth and other terrain difficulties. In this scope a few notes should be made on the further development of winch systems.

1. Winching will be facilitated if skidders could be equipped with special designed winches with smooth guiding of the cable on the drum.
2. Log length should be reduced from an average of 15 meter to for instance a standard of 8 meter which is the desired size for saw logs. By reducing the log length the manoeuvrability and speed of the winching procedure will be increased.

The results of the winch experiment were very promising. Skidding damage was strongly reduced and almost restricted to the planned and established skid trail network.

3.7.2 Exploitation damage by crawler tractors

In Suriname log extraction is often done with the aid of wheeled skidders only, directly from stump to a landing along the forest road. Few concessionaires can afford the more powerful but more expensive crawler tractor. Due to its greater penetration capability and its bigger traction on soils with low bearing capacity, crawler tractors are better equipped for log collection. In combination with a crawler tractor a wheeled skidder can be used optimally for the log transport operation on prepared trails.

Since there is a big difference in technical characteristics between the two skidding machines, it was necessary to study the damage pattern of crawler tractors in a special experiment. The observations and measurements were carried out in a large concession area where five crawler tractors and six wheeled skidders were involved in the extraction of logs. An important conclusion of the study was that crawlers tend to cause much more damage than is strictly necessary to perform a proper logging. The available power is often misused by the operator to make the work more "comfortable" for the chokerman and the wheeled skidder. The cleaning of undergrowth and positioning of the log is done in such a way that in addition to trail opening extra forest is being destroyed. For these reasons more gaps are caused by crawlers in a combined operation with the skidder.

Table 4. Skidding damage in percentage of the total forest area

Logging system*	Skidder trails	Crawler trails	Winch trails	Collecting gaps	Total damage	Logging intensity
Expt. 81/29	5,2%	-	-	2,6%	7,8%	15 m^3/ha
Expt. 82/18	4,7%	-	0.2%	0,5%	5,4%	12 m^3/ha
Expt. 83/12	3,2%	3,8%	-	5,7%	12,7%	14 m^3/ha

* Logging system:

Expt. 81/29 : Traditional logging.
Extraction by wheeled skidder from stump to landing.

Expt. 82/18 : Winch logging.
Collecting by winching from stump to skid trail; extraction by wheeled skidder from trail to landing.

Expt. 83/12 : Combined logging.
Collecting by crawler tractor from stump to skid trail; extraction by wheeled skidder from trail to landing.

3.7.3 Results

To indicate how the logging system can influence the skidding damage a comparison of three experiments is made in table 4. The presented figures refer to a low logging intensity but it may be expected that at a higher intensity the differences in skidding damage will be increased. In a properly planned operation the same trail system can serve the area if the production pro ha is doubled but the damage caused by collecting logs is directly dependent on the number of logs felled. It is obvious that improvement of the skidding system with regard to damage means improvement of the collecting techniques and methods.

J.H.

Appendix 1

STAFF AND STUDENTS OF THE PROJECT LH/UvS 01 IN 1983

Scientific Staff

Dr.Ir. P. Schmidt	Project leader, production ecology
Ir. O. Boxman	Soil fertility (part-time)
Ir. J. Hendrison	Forest exploitation
Ir. W.B.J. Jonkers	Silviculture
Ir. R.L.H. Poels	Hydrology, soil fertility (part-time)
Dra. R. Tjon Lim Sang	Vegetation ecology
Ir. F.J. de Vet*	Data processing

Technical Staff

Ing. J. Betlem	Field officer

Students

University of Suriname

S. Carilho**	Hydrology, soil fertility

Agricultural University of Wageningen

R.F. Catalan Febrero***	Tropical soil science
G. van Leersum**	Silviculture, forest exploitation
M. van Leeuwen**	Silviculture, tropical soil science
C. Jongkind**	Vegetation ecology
J.G. van der Steege**	Production ecology, tropical soil science

State University of Groningen

T. Boerboom***	Vegetation ecology
B. Kruyt***	Vegetation ecology
H.J. Müller***	Vegetation ecology

State University of Leiden

H. Hagg**	Vegetation ecology

State University of Utrecht

M. Pel**	Vegetation ecology

Institute for Natural Scientific and Engineering Studies (NATIN)

Malone***	Silviculture, forest exploitation

* arrived during 1983
** left during 1983
*** arrived and left during 1983

VISITORS AND VISITS

Visitors to the project LH/UvS 01 during 1983

- Drs. T. Balsem (Soil Survey Department) to Mapane (26.1)
- Dr. J. Rowe (Executive Director Interciencia Association) to Mapane (22.2)
- Ir. C.E. Houtman (Agricultural Attaché, Embassy of the Netherlands) to Mapane (10.4)
- Dr. P. Ketner (LHW - Vegetation Science, Plant Ecology and Weed Science) to Kabo (7/8.5) and Mapane (9/12.5).
- Ir. C.E. Houtman and Ing. E. Roelofsen (both Embassy of the Netherlands) to Mapane (28.6).
- Drs. A. Snel and Drs. G. Suno (both Soil Survey Department) to Coesewijne (14.7).
- Drs. A. Snel (Soil Survey Department) to Blakawatra (20.9).
- Miss M. van Paassen, Miss M. Vonk and Miss M. van Schaik (all LHW-students) to Kabo (21/23.9) and Mapane (26/28.9).
- Prof.dr.ir. W.H. van der Molen (LHW - Land and Water Use) to Kabo (5/6.10).
- Dr. D. Jones (United Nations Revolving Fund) to Mapane (13.10).
- Ir. F. Bubberman (Department of Agriculture, Husbandry, Fisheries and Forestry) and Dr.ir. J.F. Wienk (LH/UvS 02) to Mapane (17.11).
- Dr. D. Alexandre (ORSTOM - Cayenne) to Mapane (13.12).

Visits by project team members to other countries

- Dr.ir. P. Schmidt and dra.R. Tjon Lim Sang participated in the 'Colloque ECEREX' at Cayenne, French Guyana (4/9.3) and visited the ECEREX - field experiments along the Piste de Saint Elie (6.3).
- Ir. W.B.J. Jonkers and Dr.ir. P. Schmidt (the latter invited by the organizers and paid by MAB - UNESCO) particpated in the 'International Symposium on Amazonia' at Belem, Brazil (7/13.7) and visited the pine plantation of Santa Isabel Agro Florestal, about 50 km south of Belem (14.7).

Excursions for project team members and students

- Soils of Suriname (15.2 and 1.3, in co-operation with Soil Survey Department).
- Oilpalm plantation Victoria (18.2).
- Bruynzeel concession Patamacca (10/11.3).
- Experimental station Brokobaka (21.6, Agro-forestry).
- Oil palm plantation Patamacca (13.10).
- West Suriname (15.12, secondary succession).
- Mapane (16.12, forest exploitation).

APPENDIX 3

REGISTER OF EXPERIMENTS OF THE PROJECT LH/UvS 01

Expt. no	Short Title	Locality	Duration
65/1	Spacing/thinning in pine	Coesewijne	1965-?
67/1	Succession on a cleared area	Blakawatra/ Mapane	1967-1987
67/2A	Succession in exploited forest	Mapane	1967-1987
67/2B	Succession in exploited forest	Coesewijne	1967-1987
67/3A	Succession after shifting cultivation	Kopie	1967-1987
67/3B	Succession after shifting cultivation	Bigi Poika	1967-1987
67/4	Vegetation changes in untouched forest	Camp 8	1967-1987
67/9A	Natural regeneration techniques	Mapane	1967-1987
67/9B	Ditto, field scale trial	Mapane	1975-1995
70/21	Seed dormancy, germination	Cassipora	1970-1987
78/5	Exploitation, regeneration and increment	Kabo/Tonka	1978-1998
78/11	Mineral content of Cecropia	Various	1978-1981
78/21	Stand structure in untouched forest	Kabo	1978-1979
78/22	Phytomass and mineral content in untouched forest	Kabo	1978-1980
78/23	Soil changes under intensive silviculture	Coesewijne	1978-1980
78/34	Water balance in a small forest catchment	Kabo/Tonka	1978-1986
79/16	Stand structure in lightly ex-ploited forest	Mapane	1979-1981
79/17	Phytomass and mineral content in lightly exploited forest	Mapane	1979-1981

Expt. no	Short Title	Locality	Duration
79/24	Effects of fertilizers on mesophytic forest	Camp 8	1979-1986
80/40	Phytomass and mineral content in lightly exploited and refined forest	Mapane	1980-1982
80/41	Stand structure in lightly exploited and refined forest	Mapane	1980-1982
80/42	Bird populations in various treated mesophytic forest stands	Various	1980-1982
81/1	Primary production in untouched forest	Kabo	1981-1984
81/2	Primary production in lightly exploited forest	Mapane	1981-1984
81/3	Primary production in lightly exploited and refined forest, older phase	Mapane	1981-1984
81/4	Primary production in lightly exploited and refined forest, younger phase	Mapane	1981-1984
81/5	Primary production in lightly exploited forest during refinement	Kabo	1981-1984
81/6	Primary production in intensively exploited forest	Mapane	1981-1984
81/24A	Succession after charcoal exploitation	Mapane	1981-2001
81/24B	Succession after charcoal exploitation	Coesewijne	1981-2001
81/26	Succession on a cleared area	Kabo/Tonka	1981-2001
81/29	Timber harvesting and natural regeneration	Mapane	1981-1984
81/36	Poison-girdling techniques	Kabo/Tonka	1981-1983
82/2	Effects of fertilizer on virgin forest	Kabo/Tonka	1981-1989
82/9	Litter decomposition	Mapane	1982-1984

Expt. no	Short Title	Locality	Duration
82/14	Forest profiles	Mapane	1982
82/15	Relation soil-vegetation	Kabo/Tonka	1982-1983
82/16	Phytomass and mineral content in heavily exploited forest	Mapane	1982-1984
82/17	Light distribution	Mapane	1982
82/18	Winchsystems and shortwood logging	Mapane	1982-1983
82/21	Model logging experiment	Mapane	1983
82/22	Phytomass and mineral content in various succession plots	Various	1982-1983
82/23	Growth of shoots in various succession plots	Various	1982-1983
83/1	Simulation of various silvicultural treatments	Kabo/Tonka	1983
83/2	Soil mapping	Mapane	1983
83/3	Phytomass of roots	Mapane	1983
83/4	Light measurements in various succession plots	Various	1983
83/7	Primary production in a lightly exploited forest	Kabo/Tonka	1983-1984
83/10	Soil Mapping	Kabo/Tonka	1983
83/11	Changes in amount of litter	Mapane	1983
83/12	Exploitation damage	Patamacca	1983-1986
83/17	Influence of seed source distance on succession	Various	1983
83/18	Influence of size of deforested area on succession	Various	1983
83/19	Influence of soil compaction on succession	Coesewijne	1983
83/20	Soil mapping in various succession plots	Various	1983

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IJSSEL, W.J. van, 1983: Is het mogelijk om arboricideverbruik bij de zuivering te verminderen? CELOS, internal report, 1-32 + app.

LECTURES

JONKERS, W.B.J. and SCHMIDT, P.: Ecology and timber production in tropical rainforest in Suriname. Paper presented to the "International Symposium on Amazonia" at Belem (Brazil) on 12 July, 1983.

SCHMIDT, P.: The Project LH/UvS 01. Paper presented to the "Colloque ECEREX" at Cayenne (French Guyana) on 9 March, 1983.

SCHMIDT, P.: A foresters look at Lake Brokopondo. Paper presented to the "International Symposium on Amazonia" at Belem (Brazil) on 12 July, 1983.

During the concluding Symposium on 8 and 9 November, 1983, nine lectures were given:

BOXMAN, O.	: Effects of clearing on soil
HEDRISON, J.	: Forest exploitation
JONKERS, W.B.J.	: Silviculture
POELS, R.L.H.	: Hydrology
SCHMIDT, P.	: Introduction - Ecology - Synthesis
TJON LIM SANG. R.	: Secondary succession
VET, F.J. de	: Data processing

COURSES

BETLEM, J.	: NATIN-course	silviculture
HENDRISON, J.	: NATIN-course	forest exploitation
HENDRISON, J.	: UvS-course	forest exploitation
JONKERS, W.B.J.	: NATIN-course	silviculture