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Swedish-Malaysian Research Cooperation on Tropical Rain Forest Management Systems

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Department for Research Cooperation, SAREC

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Glossary and abbreviations

CABI	Centre for Agricultural & Biosciences (formerly Commonwealth Agricultural Bureaux) International, Wallingford, England
CGIAR	Consultative Group on International Agricultural Research
CIFOR	Centre for International Forestry Research, at Bogor, Indonesia. A CGIAR centre
EU	European Union
FD	the Sabah State Forestry Department
FRIM	Forest Research Institute Malaysia, Kepong, Selangor, Peninsular Malaysia
Gn	gunung, mountain
GTZ	The German technical co-operation agency
ITTO	International Tropical Timber Organisation
Malesia	the phytogeographical region that extends from Sumatra eastwards to the Bismarck achipelago and comprises Malaysia, Brunei, Indonesia, Philippines and most of Papua New Guinea
NGO	non governmental organisation
parang	a bush knife
psp	permanent sample plots
RBJ	Rakyat Berjaya Berhad, one of Yayasan Sabah's timber companies
RIL	Reduced Impact Logging, otherwise called low impact harvesting, etc.
SFI	Sabah Forest Industries
Sg	sungei, river
$M	the Malaysian ringgit: $M1 = 2.84SEK
SUAS	Swedish University of Agricultural Sciences, Umeå
YS	Yayasan Sabah, the Sabah Foundation

Executive Summary

1 Two separate collaborative projects between the Swedish University of Agricultural Sciences (SUAS) and Sabah, Malaysia are reviewed. Both projects have developed excellent working relationships with their Sabahan counterpart. Funding for both ends mid 1996.

2 **Project A. Silvicultural refinement of selective logging** (SUAS-Silviculture and Sabah Foundation (YS)) consists of two experiments.

3 Experiment 1 is completed. It demonstrated that on steep slopes it is possible for an expert to fell trees in a predetermined direction. The Swedish expert gave training to local fellers and an instruction manual was written. Two Sabahans gained M.Sc. degrees and a Swede hopes to gain a Ph.D. on data from the experiment.

4 Experiment 2 still continues. It occupies an area of 280 ha where elaborate permanent sample plots (PSP) have been set up to monitor the different effects on steep slopes and flattish land of supervised felling (preplanned extraction tracks, directional felling) and unsupervised felling (F), with and without prior climber cutting. Measurements have been made at F-1, F and F+2 years. Some results have been collated but no analyses are expected by the time funding ends. Inspection clearly suggests that supervised felling reduces damage to the forest.

5 Both experiments were very timely and have aroused considerable interest because Sabah is conscious of the need for logging to be `sustainable' by 2000 AD to meet the deadline set by ITTO and to satisfy consumers in certain markets. Both YS and Sabah Forestry Dept. (FD) have drawn on these experiments and begun to incorporate directional felling and preplanning of tracks into timber extraction practice.

6 Concerning cost effectiveness SAREC's three overall aims (capacity-building; support research and transfer results on important problems; promote co-operation between Sweden and Sabah) have been met; no important components have been omitted.

7 Concerning scientific results, the efficacy of controlled logging was already known from several earlier projects, including one in Sabah, but no such rigorous demonstration had previously been made. The usefulness of climber cutting is under test, though it is known in Malaysia not to be cost effective on an operational scale.

8 For the future, experiment 1 needs to be fully published, and experiment 2 to be analysed, the protocol for permanent sample plot (psp) measurements simplified, and then handed over to YS either before or after the F+4

measurements. YS has only 6 psp and the 20 established in experiment 2 will be useful augmentation. In 1996 FD expects to bring YS forests under its new Management Plan and this needs psp data.

9 Concerning a new third experiment, for Sabah the priority is now how to relog logged forest. A third experiment would need to remember that (a) there is much knowledge of dipterocarp rain forest ecology, silviculture, management and timber properties in the region, and also (b) that logging in Sabah has just begun to implement a new Management Plan drawn up by GTZ/FD. Any new experiment should be designed to help develop the Operational Guidelines of the Management Plan, which have not yet been fully formulated.

10 There is not much unlogged forest left in Sabah or indeed in dipterocarp rain forests anywhere. Any experiment in unlogged forest would take a minimum of 5-6 years to develop operational guidelines by when there would be even less left. Industry and FD procedures have been in place for 25 years and are well entrenched. Because of these considerations it is unrealistic to start research now on different silvicultural/logging systems for virgin forest.

11 The very considerable new interest in low impact harvesting extends across the whole S.E.Asia region and there is scope to publicise the results from Sabah and to give further training in directional felling. This would be particularly appropriate for dipterocarp forests (Malaysia, Indonesia). These have a much higher volume of commercial timber per hectare than other tropical rain forests. Moreover the experiments were in an unusually tall, high volume dipterocarp forest such as now only remains elsewhere in nearby eastern Kalimantan. Thus, although the general principles of low impact harvesting are well demonstrated by the experiments, the results in detail cannot be extrapolated for example to continental Asia, Africa or tropical America where timber trees are shorter and sparser. SUAS has been offered the chance to join a second reduced impact logging (RIL) experiment in Sabah and to accept this offer would give a contact with CIFOR which might open the way to training opportunities.

12 **Project B. Hydrology and nutrients on conversion to plantations** (SUAS-Forest Ecology and Sabah Forest Industries (SFI)) consists of two main groups of experiments and a third smaller one.

13 The first experiments encompass six small catchments (W1-W6). Acacia mangium was planted after different land clearance treatments and reaches rotation age for pulpwood in 1997 at 8.5-9 years age. These experiments clearly showed more serious loss of nutrients and sediment after tractor clearance + burning, and much poorer growth of A.mangium, which effectively failed on the twice burned area (W1+W2).

14 The SFI analytical laboratories were set up by the project and training

given at various levels. More elaborate analyses, check analyses, training and updating are still provided. SFI has abandoned burning and is phasing out tractor clearance. The international scientific community is becoming aware of these experiments, mainly from numerous publications, some in international refereed journals.

15 It is planned to plant second rotation plantations after harvest and to continue to monitor hydrology, nutrients, erosion and tree growth. There are very few long term studies extending beyond a first plantation rotation and this extension of the first experiment will be of considerable value. It requires and justifies the long term funding SAREC is providing.

16 The second experiments (W7-W11) began May 1994 with one year pre-treatment monitoring. Four catchments have been felled and tractor-cleared. Hill rice was planted in late 1995 with (W9, W11) or without (W7, W10) prior burning and with (W10, W11) or without (W7, W9) Acacia mangium. At time of inspection it seemed possible rice would fail to establish without burning, and that harvest pests would reduce yields of all 4 treatments. These experiments should confirm the bad effect of burning on growth of A.mangium after tractor-clearance (W10, W11), strongly indicated by the first experiments. They will monitor the nutrient budget of hill rice and subsequent bush fallow with and without burning (W9, W10), on sites previously cleared by tractor for pulpwood. Intensive work has now finished and will be replaced by long term monitoring which will be done by SFI with SUAS backup, and not requiring much SUAS input.

17 These second experiments are not completely realistic because SFI is now phasing out tractor-clearance, padi is not planted into forest without burning, and peasant farmers do not invade forest clear-felled for pulpwood. Nevertheless, well-documented true time-series experiments on hydrology, nutrients and erosion of tree plantations or hill agriculture on rain forest land are very sparse.

18 The third experiment is investigating soil improvement by Acacia mangium planted into Imperata grassland protected from fire. Smallholders around the SFI area have much such grassland and are encouraged to plant small tree lots for sale to SFI. In the region there are very extensive such grasslands which are currently underutilised.

19 All three experiments are jointly conducted by SFI and SUAS and continue to be the channel for training and back-stopping of the analytical laboratories. Overall these experiments are excellent science and will become regarded as a classic study in rain forest nutrient cycling. They begin to be well known in scientific circles, but less so amongst the increasing number of Acacia plantation growers of the region, mainly Indonesia, partly Malaysia and elsewhere. There is scope for publicising the results more widely to this latter

group of interested people. This should be a priority for a future phase. CIFOR would be one possible channel and has indicated interest.

20 SUAS input is now at a fairly low level plus episodes of higher activity. In the longer run a complete handover to SFI has to be contemplated. A further phase of funding should reflect these two aspects.

21 SFI have a strong interest in reversing the reduced tree growth that occurs on compacted soils. A small experiment is planned to start 1996 within the first group. This should be given priority.

22 This project has also met all three of SAREC's overall aims (see above). One Swedish Ph.D. has been obtained and capacity increased at SUAS. Training on short courses and on-the-job has been given to a succession of SFI employees at various levels.

A Silvicultural refinement of selective harvesting (SUAS-Silviculture and RBJ)

A1 The project described

1.1 General

In 1991 the Swedish University of Agricultural Science (SUAS) Department of Silviculture began a collaborative research project with Rakyat Berjaya Sendirian Berhad (RBJ), the logging company of Yayasan Sabah (YS).

Forest exploitation in Sabah is under the ultimate control of the State Forestry Dept. (FD) and follows the Modified Malayan Uniform System (MMUS) which prescribes that all commercial stems $\geq$ 60 cm diameter are cut at one time, and a rotation of 60 years. As elsewhere in western Malesia most of the timber comes from Dipterocarpaceae.

YS is a parastatal organisation that gets its main income from logging a large area of lowland evergreen dipterocarp rain forest held on long lease from the state government. On this area FD has delegated some of its powers to YS. The YS concession is 972 084 ha, of which 80.25% (780 675 ha) is production forest. Logging began about 1970, and today 230 000 ha remain unlogged (YS information brochures and pers. comm. Awang Sham). The sustainable allowable cut under MMUS is 78 065/60, or 13 011 ha/yr. The actual cut has been 22 027 ha/yr, 1.7 times higher. Currently RBJ is in negotiation with its logging contractors to reduce the annual cut from c. 20 000 ha to 10 000 ha. This will extend the life of the virgin forest to 23 years, until 2018. Under MMUS the second cut can begin in 1970 + 60, i.e. in AD 2030. Plantations are planned,

and some exist, to produce timber during the gap between first and second rotations. YS does not intend to relog its forests before 60 years, although this has happened, several times, in most of the other dipterocarp forests of Sabah. The state is heavily dependent for revenue on timber royalties and pressures on YS to relog before 2030 may develop. It would be prudent to investigate the feasibility to relog in a manner that does not degrade the forest.

State timber production has fallen from a peak of c. 11 000 000 m^3/yr to c. 7 000 000 currently (C.Marsh, formerly of RBJ, pers. comm.). Since 1993 the export of unprocessed logs outside Malaysia has been banned.

There is a growing concern in Sabah at the prospective shortfall in timber production and also on the need to log the forest in a less damaging manner than at present, in order to maintain timber production capacity as well as biodiversity and ecosystem functions, i.e. to meet the goals set by ITTO for the year 2000. Research by Sabahan organisations alone and in collaboration with various foreign agencies has addressed, and continues to address, these issues. More detail is given below.

In Indonesia there is a stronger awareness than in Malaysia of ITTO 2000, and a very strong awareness that `ecolabelling' of timber will soon become essential. Low impact harvesting techniques are therefore now falling on receptive ground, quite different from the situation two years ago (D.Dykstra of CIFOR, pers. comm.)

There is global concern on current human impact on tropical rain forests, and this has increased and been focused by the 1992 UNCED conference at Rio de Janeiro. Sweden shares this concern.

It was against this background that SAREC invited SUAS to share its expertise in silviculture with Sabah, and jointly to develop research in sustainable management of tropical rain forest. Funding was initially from a budget aimed to increase Swedish expertise and capacity, but when the project was renewed funding was changed to a different budget for special projects, in this case to demonstrate a positive Swedish response to Agenda 21 of UNCED.

SUAS has no previous tropical experience so can cast a fresh light on the problems currently facing Sabah and other nations with dipterocarp rain forests, and can bring the Scandinavian expertise in boreal forest silviculture to bear on them. Boreal conifer forests have a handful of tree species, most of them commercial. Dipterocarp rain forests have c. 10 commercial groups of species (viz. species with similar timber) and over a hundred individual tree species per hectare (and in total several thousand tree species).

The SUAS project began with a two week fact-finding tour in March 1990 and developed via successive short term grants into a three year collaborative

project with RBJ which expires in July 1996, and which is governed by a Memorandum of Understanding (signed at Luasong March 1992) plus a Plan of Operations (signed at Umeå June 1992).

Sweden has provided the full time services of a graduate forester, Mr Jonas Cedergren, and input from faculty members Dr J.Falck and Prof. M. Hagner. Sabah has assigned the part time services of two forest officers, Messrs Francis Goh and Andrew Garcia and of several forest rangers.

Two separate experiments have been conducted of which the first is finished. The experiments and results so far are described in detail in various SUAS publications (6 were received for this present review). Here the experiments are very briefly described.

1.2 First experiment (directional felling)

This experiment was aimed to give quick results and to help in the design of later research. Much discussion took place between all team members, both Swedes and Sabahans, in its planning.

> The experiment aims to establish by a rigorously designed and statistically controlled operation whether it is possible to fell trees in a predetermined direction and if so whether damage is reduced. There are four treatments; 88 trees on a steep slope and spread over 600 ha were felled in total. The forest is at mile 41 beyond Luasong in Gn. Rara Forest Reserve and the total commercial volume is 150 m^3/ha. Half the trees were felled by a Swedish expert and half by local tree fellers of RBJ's logging contractor who were chosen to have a range of experience. Half of each batch had had big woody climbers (> 2cm diameter) cut one year before felling. Climber cutting cost c. M$ 50/ha, using parangs, small chainsaws and axes. Measures were made of forest composition and structure before and a few months after felling. The expert used a modern chain saw and wedges and felled 10-12 trees/day. The local fellers felled 15-20% more trees/day and did not use wedges. They own their chain saws, and these are an outdated model c. 10 years old.

The experiment established that it is possible for an expert to fell trees to within a few degrees of a predetermined direction. It should be noted however that directional felling on hillsides is easier than on flat land. The most difficult to control were diseased or huge trees. Climber cutting did not alter this, nor did it reduce damage to the forest.

Data from this experiment have been used so far by the two local forest officers to gain M.Sc. degrees from SUAS and Cedergren is working on the rest of the data for his Ph.D., which he hopes to complete early 1996, somewhat later than originally planned.

A practical manual on directional felling has been written.

Local fellers were interested in the techniques of directional felling and came to watch the Swedish expert at work. A short course was given to fellers from four contractors.

No formal analysis was made of the extra costs in time, labour and fuel incurred by directional felling.

1.3 Second experiment (supervised felling)

Whereas the first experiment just looked at directional felling, the second one compares supervised (preplanned tracks, plus directional felling) and unsupervised (normal practice) felling with and without prior climber cutting and on flat ground and steep ridges. Thus it introduces an improved reduced impact timber extraction system on a research scale and compares it to the present system.

The experiment is in two compartments of 180 ha and 100 ha, also near the Mile 41 camp. Twenty plots, each of 100 x 100m (1 ha) divided into 10 x 10m subplots were established in high-commercial volume (200-250 m^3 ha) dipterocarp evergreen rain forest, half on low undulating land, half on ridge crests and steep upper slopes in forest of different composition that included much Agathis. (Forest Dept. growth and yield plots have the same structure). All trees > 10cm diameter were enumerated and identified to vernacular timber group on the whole plot. In addition on 40 randomly selected subplots of progressively smaller fractions (12%, 6% and 0.8% of the plot area) saplings (100-25mm diameter), seedlings (25mm diameter - 30cm height) and small seedlings ('germlings', < 30cm height) were enumerated. Numerous measures were made, including damage and climbers. This was done before and soon after felling (F) and at the time of the reviewer's visit the F+2 year measurements were in progress. Each plot takes 5-6 men 5 days (i.e. c. 36 man days). Five teams are employed totalling 8-10 permanent RBJ staff and 30-32 labourers for whom SUAS pays field allowances and full costs respectively. Each enumeration of the 20 plots takes 720 man/days and costs $M 60 000.

The forest is divided into ridges versus flat land and in each there is supervised and unsupervised felling plus or minus cutting of climbers > 2cm diameter at year F-1. Supervision involved directional felling by a Swedish expert with reference to preplanned skid tracks at 60m spacing in the flat land, and across the contours at approximately that spacing on the hilly land. The slender clump-forming climbing bamboo Dinochloa is occasional in the virgin forest, especially near streams. It becomes abundant and scrambles up to 20 m or higher in logged forest where in places it has become a serious weed.

Inspection of the results so far show there is much less damage in the supervised felling treatments.

The resources needed to process data in Umeå are as follows:

1 2 x 3 man months (mm) (or less by a skilled operator and for later data sets) to key in, in duplicate and under professional supervision

professional time totalling 7 mm as follows:

2 c. 1 mm to check each data set
3 1 mm to analyse each data set, maybe more
4 4 mm to write reports on whole data so far.

By July 1996 when the project funding ends, it is expected to have all three enumerations keyed in (step 1) but none of the data will have gone fully through this time-consuming analytical process.

By July 1996 it is also expected to have a paper written to include a general description of the forest before treatment and the design of the experiment. This might form part of Cedergren's Ph.D. dissertation.

Apart from the 20 growth and yield plots set up by experiment 2 YS has 6 others. The Forest Dept. Sepilok Research Centre has numerous permanent sample plots, some with over 20 years of records. Sepilok has not been involved in the SUAS project. SUAS has not seen any of the FD data or analyses but was informed (R.Ong, Nov. 1995) that only 30 growth and yield plots are being maintained (these are presumably the 30 plots used by the GTZ/FD management model described below).

For the long term sustainable exploitation of the forest it is essential in Sabah as elsewhere to have growth data from plots with known logging history. It is a poor reflection on YS that they so far have only 6 plots, despite having been in business since 1970 and having logged c. 600 000 ha. The SUAS project has made a start in instilling the necessity of permanent growth and yield sample plots into YS thinking, and has given training in their establishment and measurement. Recommendations for the future of the 20 new plots is given in section 4.1.

A2 Exploitation of dipterocarp rain forests

The overall aims of SAREC (see ToR appendix 1) are to help build research capacity and solve important problems by scientific co-operation. It is thus necessary to see this SUAS project in its state and regional context, that is to say both within Sabah and across the range of the remaining dipterocarp rain forests in western Malesia (Borneo westwards to Sumatra).

2.1 Sabah

Yayasan Sabah has c. 630 000 ha of once logged forest and c. 3000 000 ha of remaining virgin forest. Outside the YS area virtually no virgin forest remains in Sabah, all has been logged at least once, and much of it several or up to seven times over the past 25 years.

2.1.1 GTZ. A joint GTZ/Forest Dept. project (1989-1998) has developed and is just beginning to implement a Forest Management Plan for the whole of Sabah, including the YS area. This plan was published mid 1995 (though no copy could be obtained for the present review) and will be complemented by Operational Guidelines, based on standard FD procedures, that was still being written at end of 1995. Even when complete there will be the need to add detail to the

Guidelines as management experience develops (see section 4.2). The management plan meets the Malaysian Environmental Quality Act. It is based on research at Deramokot Forest Reserve, used as a model, and also on 30 pre-existing permanent sample plots of 1 ha each spread across Sabah in residual forest without postfelling treatment. Deramokot was logged once in 1972-3 and yielded on average 70 m^3/ha from its 56 000 ha, or 3.9 000 000 m^3 total. Deramokot is now very heterogeneous, and has patches with little or no commercial stocking, serious Dinochloa bamboo infestation (but none of the serious Cucurbitaceae climber Merremia), and swampy areas with dead trees where streams have been blocked. Overall, however, its condition is much better than most of the permanent forest estate (M.Kleine pers. comm.)

A forest growth simulation model DIPSIM has been developed, as a tool for forest level management planning. This will be fully published by FD and is briefly described in a paper by Ong and Kleine which will be published by GTZ/Mulawarman University, Samarinda. DIPSIM is now being applied, in the first instance at Deramokot where a total of 20 000 m^3 are being extracted (i.e. 0.4 m^3/ha representing increment of 0.04 m^3/ha/yr), according to a predetermined plan. Less than the full increment is being harvested in order to build up the growing stock. Low impact harvesting techniques (using RIL procedures - see below) are in place. Some extraction is by cable yarding, some by tractor. The maximum volume removed is 30-35 m^3/ha. The basic canopy structure (such as it is) is never destroyed, and potential crop trees and seed trees are retained. The bamboo can be killed by cutting at ground level.

Sabah is now divided into forest management units and it is proposed that the Management Plan will be progressively applied to these. All are in logged forest, except the part of the YS area that still remains unlogged. After - Deramokot the next management unit to be included is part of the permanent forest estate at Mendalong (but outside the SFI area) where ITTO has provided funds and a Danish consultant firm, DANSET, has been employed[1]. There are social problems of encroachment into the forest at Mendalong, not encountered at Deramokot, whose handling is included in the management model.

For each management unit data for the DIPSIM model are gathered from 500-600 (temporary ?) plots established on a 1 km^2 grid, and enumerating trees > 10cm diameter.

The YS lease area comprises three management units and FD plans to implement the Management Plan in these during 1996. The SUAS-created 20 growth and yield plots should be a useful contribution to implementation of the Management Plan. By the ITTO target year of 2000 it is planned to have the whole permanent forest estate of Sabah under the new Management Plan.

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[1] as first project under an MoU on collaborative environmental projects between Denmark and Malaysia

2.1.2 RIL. Reduced Impact Logging (RIL) is the name given to an experiment in Sabah conducted with funds from US electricity generators (New England Power, Edison Foundation) who are interested to offset their carbon dioxide emissions by reducing the loss of biomass (and hence CO_2 emission) caused by forest damage at logging. It has recently been described in Pinard et al. (1995). Two areas have been logged by RIL, the first at Danum valley (450 ha) and the second near Luasong (900 ha). F.E.Putz, a senior associate of CIFOR contributed in setting up this experiment. The contractor is paid to fell part of his coupe under constrictions to reduce damage. These involve climber cutting, a complete map of all trees > 60cm diameter, preplanned extraction tracks on ridges wherever possible, directional felling (for which a 10 percent increment to the normal wage rates), and retention of riparian buffer strips. Unlike usual practice road traces are not opened to 60-80m wide. (These details on RIL were supplied by the SUAS team.) It was not possible for this reviewer to see a RIL area because the roads were said to be impassably muddy after very heavy rain. RIL is associated with CIFOR which is represented by D.Dykstra on its independent audit team (along with Wan Razali of FRIM and R.Donovan of Smartwood, a US NGO). Initial design and training were developed together by experienced foresters from RBJ and north Queensland. Cedergren of the SUAS project contributed experience from the two SUAS experiments. The RIL experiment is to enter a second phase in 1996: at Kuamut near Luasong 1000 ha will be felled in each of three years.

Several of the RIL protocols are included in existing logging regulations although they are not enforced. Thus to some extent the contractor is being paid for the extra costs of RIL to do what he is contractually obliged to do anyway.

Contractors can see the financial advantage of RIL because of higher timber recovery and are putting pressure on their fellers; RIL is working because outside money is being used to fund it. It still needs fine-tuning, e.g. in the use of choker cables (D.Dykstra pers. comm.)

Low impact harvesting techniques are being extended to the whole YS coupe in 1996 (preplanned tracks, directional felling, but not climber cutting or stock map). Low impact harvesting is also to be enforced by FD from July 1996 in logged forest, where activity now focuses. In preparation for this the Forest Training Institute at Sandakan was in November 1995 training FD field staff (including on enforcement) and in 1996 plans to train contractors' staff. This training is being assisted by Richard Thomas, seconded from YS where he was engaged in both the RIL experiment and also the first SUAS experiment (directional felling). Thomas is assisting the modification of the original RIL protocols so that they can be applied to logged forest.

FRIM had a low impact harvesting experiment at Mendalong funded by Japanese Trust Funds through the World Bank. No details could be obtained. The FRIM officer concerned (Harry Cheah) now works for Indorayon in Sumatra.

2.1.3 FACE Foundation. A Dutch electricity generator who also wants to sequester carbon is funding enrichment planting with dipterocarp wildings of logged and depleted forest in the Ulu Segama forest reserve, mile 56 Danum valley. So far 1000 ha have been planted.

2.2 Elsewhere

Most of the world's tropical hardwood timber in international trade comes from the dipterocarp forests of Malaysia and Indonesia. Industrial nations in the west that import this timber have been sensitised by vocal environmentalists and have responded by developing collaborative aid projects in dipterocarp forest management and silviculture. Many projects ignore the vast knowledge and wisdom accumulated in the past. There is more known and published about composition, variation, ecology, silviculture and management of dipterocarp rain forests than of any other kind of tropical rain forest in the world. The work was largely done in Brunei and Malaysia but also in the Philippines and Indonesia. In Indonesia, mainly in Kalimantan, there are current or recent projects by USA (USAID, NSF), Germany (GTZ), France (CIRAD-Forêt, STREK project, finishing 1995), Finland, Great Britain (ODA), Holland (Tropenbos-Wanariset), and in 1996 there will be both CIFOR and EU projects too. GTZ funds a pan-Kalimantan clearing house (but its Samarinda project finishes end 1996). ODA are employing de Kock of Tropenbos to make a synthesis of all knowledge of dipterocarp growth and yield (and held a workshop in Samarinda 16 Nov. 1995). Since the early 1980s CABI, FRIM and now CIFOR have all prepared syntheses of knowledge of dipterocarp forest ecology, silviculture and management. Japan has funded research in Brunei and Kalimantan.

A3 Analysis and assessment

This section addresses the series of questions posed in the Terms of Reference (Appendix 1).

3.1 SAREC administration

SAREC's three overall aims (see ToR Appendix 1) have been met, no important components have been omitted.

3.2 Scientific results and capacity building

There have been several previous trials of preplanned and controlled timber extraction. Indeed, good practice is built into the standard logging rules of Sabah. In dipterocarp forests such experiments have been or are being conducted in Kalimantan (Tropenbos), Sarawak (Marn & Jonkers 1981) and Sabah (Malvas 1987), the latter two as components of FAO/UNDP projects. Malvas (1987) showed tree survival per hectare was improved as follows by supervised felling:

yarding	supervised	unsupervised
tractor	19	12
high lead	14	11

The recent STREK project in north east Kalimantan reported similar results in a preliminary report (Bertault 1994): injury was reduced and survival increased when tracks were preplanned. The STREK project attempted directional felling but without success, probably because no skilled instructor was available to teach the techniques.

Elsewhere there have been experiments reported from Surinam (CELOS, Jonkers 1987, Hendrison 1990) and Brazil. In Brazil, starting in 1995, extensive operational scale low impact harvesting is being practised in several separate projects (e.g. Precious Woods, Tropical Forest Foundation). Low impact harvesting is practised on a large scale in Guyana (Demerara Timbers Ltd) and in the subtropical forests of Paraguay (Sustainable Forest Systems). All of the trials, demonstrations and commercial-scale enterprises have clearly shown that it is cost-effective and minimises damage to the residual stand to preplan skid trails and to fell directionally.

Climber cutting was once a prefelling prescription for dipterocarp forests in Peninsular Malaysia, Sarawak and Sabah. It has been shown not to be the most cost-effective way to spend limited funds and when very extensive logging began in the late 1960s was progressively abandoned.

The SUAS project is aware of most of the classic silvicultural work in Far Eastern rain forests and has prepared a fairly complete annotated bibliography.

It is already well known that careful timber extraction is cost effective and less damaging than uncontrolloed felling. What the first experiment has done is to demonstrate very rigorously and under strong statistical control that it is possible to fell close to a predetermined direction, even a gigantic 50m dipterocarp tree. It was also shown that directional felling reduces damage. This has not been previously so rigorously established. Experiment one also showed that climber cutting had no effect on ability to fell in a predetermined direction or on damage. There are no results yet from the second experiment, nor will there be any by mid 1996 when funding ends. It is expected to show, again rigorously and statistically, that supervised felling reduces damage. The 20 permanent sample plots are the base from which growth of the logged forest can be compared under the four different treatments, on both flattish and steeply hilly land.

Excellent on-the-job training has been given in procedures for establishing and measuring permanent sample plots, and in the planning of skid trails for supervised logging. Directional felling by a Swedish expert has been demonstrated to staff of four logging contractors as well as to YF personnel in the Luasong area and a short course has been given.

Two forest officers (Goh, Garcia) have gained Umeå M.Sc. degrees and Cedergren should gain a Ph.D., all on the first experiment.

The two Sabahans presented a joint M.Sc. thesis (Garcia & Goh 1995). This consists of two short reports written jointly with their supervisors, Falck and Hagner, and their co-worker, Cedergren. The first paper is a description of structure and composition of the forest where experiment one is sited. It includes a brief account of silviculture in Malaysia, and relates its findings to the literature. The dipterocarps were mostly identified down to species, but many other groups only to genus. This paper contains no novel findings, the forest is just as one would expect. The second paper analyses the accuracy of directional felling and the efficacy of climber cutting. It is a carefully conducted statistical analysis of experiment one. In Great Britain it is usual for a thesis submitted for an M.Sc. by research to be examined by one internal and one external examiner, preferably neither of them the supervisor of the candidate, and to award the degree if a modest contribution has been made to knowledge. On this latter criterion paper one would be judged as introductory background information and paper two to be the requisite crumb of new knowledge. The two papers taken together would be just about sufficient for an M.Sc. by research. They are very brief. In Britain the candidate is expected to work alone. What is unusual, on British standards, is to have co-authors including faculty members. Also in Britain a joint research thesis is virtually unknown. On British standards it would be difficult to award two M.Sc. degrees on this thesis.

The Ph.D. remains unwritten. A preliminary short draft of a paper by Cedergren was made available for inspection. It discusses silvicultural and commercial characteristics of a primary dipterocarp forest, the same forest as analysed for the M.Scs. The paper in the very rough and preliminary form inspected did not break new ground.

Much data will have been obtained from three measurements of the 20 sample plots of the second experiment, but not processed, analysed or interpreted. It is planned to use these data for a Sabahan Ph.D. in the second phase.

There has been very little published yet, and nothing in the refereed scientific literature or in books. The experiments have not yet been reported very much at regional or broader conferences or seminars. An operational manual on directional felling has been written. SUAS through Cedergren was involved in planning the RIL experiment. Richard Thomas of RIL was involved in the directional felling experiment and is now giving training on RIL techniques to FD staff (see above).

The permanent sample plots are extremely expensive in terms of the skilled YS manpower required and in cash. They are collecting more data than is likely to be of interest to YS. In this sense they are not cost-effective, though in terms of a deeply comprehensive study of the effect of different logging regimes they are a fundamental contribution to rain forest silviculture.

SAREC has given 300 000SEK to FD to organise a seminar. This has been twice postponed but will now take place 18-22 March 1996. Frederick Kugan of FD is in charge. He intends that the audience will be mainly from Sabah with some people invited also from Sarawak and Peninsular Malaysia. It is intended to cover the RIL experiment and directional felling and to include forest demonstrations and visits, including to Deramokot. SUAS have been invited to present a paper but no field visit will be made. SUAS should use this meeting as a major opportunity to publicise its project to a broad Malaysian

audience.

Excellent rapport has been built between the SUAS and Sabahan participants.

Thus, in summary, much data have been gathered. The two experiments have been used as the basis for considerable training in several ways and have contributed in a timely way to other related initiatives in Sabah. Until fuller analyses are complete the experiments cannot be published in the refereed international literature. That will not happen before present funding ceases.

3.3 Practical impact

The advantages of directional felling and preplanned skid tracks are well known. The practical demonstration on a research scale given by this project has begun to spread across Sabah as described above. If it is publicised within Malaysia (e.g. at the March 1996 seminar) it can be expected to help change forest management practices. It would be equally relevent elsewhere (but see section 3.4 below) in the archipelago to countries with evergreen rain forests, notably Indonesia and Papua New Guinea, as well as to Laos, Vietnam and Cambodia on the continent where this kind of forest is being exploited. As already stated, the ITTO target of all timber to come from sustainably managed forests by 2000 AD has awakened an interest in low impact harvesting that did not exist a few years ago.

3.4 Regional aspects

The results are widely applicable elsewhere in the region and to tropical rain forests across the tropics but have to be seen in the context of numerous other ventures described in section 2.2 above. The strengths, when the data are ultimately analysed and published, will be the rigorous quantitative demonstration of the benefits of supervised felling. The results are most relevant in tropical evergreen rain forest, especially dipterocarp forests which have uniquely large trees. They do not relate so closely to the semi evergreen and non dipterocarp evergreen rain forests of continental south east Asia or central America which have very different structure.

Any additional demonstration of the benefits of supervised felling aimed at a broader audience would need to be carefully planned and tailored to fit into the regional picture.

A4 The future

The present funding ends mid 1996. It would be highly desirable by that time and as a justification for further funding if the first experiment was fully analysed and first paper(s) prepared on the second experiment describing the forest and the experimental design.

Any extension should then at an early stage ensure that the results of the first experiment are fully published in the refereed international literature. Few resources would be needed for this.

There are four topics that could be followed up in any extension to the project. These are considered below. In summary they are the growth and yield plots of the second experiment (section 4.1), a new experiment in recutting logged forest (section 4.2), or a new experiment in logging virgin forest (section 4.3). As described below, research in logged forest is of far more importance to Sabah and the region than research in virgin forest. Finally (section 4.4), further demonstrations and courses on directional felling would be worthwhile.

4.1 Growth and yield

The 20 one ha growth and yield plots of the second experiment will be ready for the F+4 yr measurements at the end of 1997. If funding is provided it should make provision for a complete analysis and publication of results up to and including F+4. The measurements to be made should be reduced either now or after F+4 to those of most value and interest to YS, i.e. those dealing with growth of merchantable or potentially merchantable trees, and the project should then be handed over to YS in a simplified format for long term continuation, using suitable forms and protocols developed by SUAS.

The data of the second experiment will be more than enough for a Ph.D. It is recommended that training at Umeå should be offered to a Sabahan counterpart. This will ensure the involvement of YS in developing the new protocols for psp measurement and in analysing the results so far and in this way help build research leadership capacity in Sabah.

4.2 Recutting logged forest

An important priority in Sabah is to develop methods for the sustainable recutting of logged forest. Nearly all the permanent forest estate has been logged twice or more and YS has c. 600 000 ha of once logged forest (as against 230 000 ha of remaining virgin forest). The GTZ/FD project has published an overall Management Plan and will soon complete Operational Guidelines for its implementation. Much will remain to be learned on details of operations within this plan and guidelines and SUAS could contribute to the development of them. It is suggested that a valuable new third experiment would be to develop techniques for relogging logged forest on which much remains to be learned. For this SUAS would need to obtain and study these two GTZ/FD publications and then in discussion with YS and FD develop a research project or projects on operationally realistic and commercially viable low impact sustainable harvesting of logged forest. This would aim to produce at least some tangible applicable results by the time a second funding period ended and write them up as a contribution to the Operational Guidelines. It is to be expected that discussions by SUAS with experts in dipterocarp forests in Sabah and elsewhere would

facilitate development of a third experiment likely to yield results that could be implemented by the industry given its strengths and traditions.

It is desirable that an attempt to demonstrate financial benefits is included in any new experiment.

4.3 Felling virgin forest

The present cutting system, removal of currently commercial stems > 60cm diameter, is very crude. Different systems could undoubtedly be designed. One example would be a system that retained population structure by removing a fraction of each diameter class. Not much virgin dipterocarp forest remains in Malaysia or Indonesia, none in the Philippines, and in Brunei cutting is on a small area annually just to meet domestic demand. The priority in the region is to devise systems to relog logged forest (4.2 above), so this also has to be the priority for SAREC. Any new system to log virgin dipterocarp forests in a better way would need to take account of the very rich mixture of tree species. These have very different timber properties, so even if more or most species become marketable they will need to be named in the forest and sorted for sale. This is not an easy task. Moreover, they differ very considerably in growth rate and its response to canopy opening so to devise a simple useful new silviculturea system is a daunting prospect. A new system would also need to overcome considerable inertia, and counter the traditional way loggers have conducted their business over the past 40 years, including the working practices of all the people who work in the forest. Finally, any new system would take perhaps 10 years from initiation of experiments to development and testing of operational scale protocols, by which time there will be very little unlogged dipterocarp rain forests remaining.

It might be more profitable to attempt to invent new felling systems in South America where the logging industry is only just developing, regulations and practices are not so deeply embedded, and a huge extent of rain forest remains, than in the dipterocarp forests of the Far East where, by the time a new system is ready for implementation, very little virgin forest will remain. It also needs to be realised that the dipterocarp evergreen rain forests of eastern Sabah with 70-150 m^3/ha or more of gigantic commercial trees have no remaining counterpart anywhere else in the world except parts of Kalimantan, so techniques developed there are not likely to be easily transferred elsewhere.

4.4 Directional felling

The demonstration and training in directional felling already given has been of interest to those contractors who have been involved. Experience gained in directional felling plus planning of skid trails has been used in designing the RIL project and thence recently spread to the Forest Training Institute. It is suggested that SAREC explores the possibility of giving more training, e.g. by training trainers. Throughout western Malesia low impact

harvesting is rapidly being adopted, partly spurred by the need to implement the ITTO guidelines by 2000 AD and to achieve `ecolabelling' via certification. Thus an opportunity exists to transfer Swedish expertise more widely in Sabah and other parts of the region. The managers of the RIL project have already approached SUAS for assistance in its second phase and this is one opportunity that might be explored. The operational manual written as part of the experiments should be widely disseminated.

CIFOR is a party to the RIL project and would be one channel which might be able to facilitate transfer of the knowledge gained in Sabah to a wider audience, as well as to assist in the organisation of training course(s) in directional felling.

The project with Yayasan Sabah has fully achieved its objective to build up a small core of expertise in tropical rain forest silviculture in Sweden. Only one graduate student (Cedergren) is fully engaged, but two faculty members (Hagner, Falck) with part time involvement give greater continuity. SIDA needs to consider what kind of future investment is best to maintain this expertise. There are two options, firstly to rely on contracts which inevitably have no certain continuity, or secondly to provide an element of core funding in addition to contracts.

B Hydrology and nutrients on conversion to plantations (SUAS-Forest Ecology and SFI)

B1 The project described

1.1 General

Sabah Forest Industries (SFI) is located in southwest Sabah adjacent to Brunei Bay where it has 289 000 ha of lowland and lower montane rain forest on long lease from Government. In the far south, adjacent to Indonesia, 30 000 ha of this area form the Sg.Ulu Padas permanent forest reserve. In 1987 a fully integrated pulp and paper mill was opened at Sipitang near the coast, whose current output is 120-150 000 t/year of paper. SFI was privatised in 1995 when Lion Group obtained 85 percent ownership by tender and this has already strongly reinvigorated the company.

The forests were largely `creamed' for logs > 60cm diameter of only 5 timber groups in 1981 before SFI obtained its lease and parts were then destroyed by the Great Fire of Borneo of 1983. SFI obtains cash by selling logs which contactors extract from its rain forest and is currently extracting 300 000 m^3/year at c. 30 m^3/ha. SFI will soon build its own sawmill. Logging is controlled

by a model developed by the Asean Institute of Forest Management in 1992 and is based on a 3 percent inventory. Until recently there was also uncontrolled illegal felling but Lion has stopped this.

In addition, part of the rain forest is `clear felled' to provide pulpwood. Until recently, this involved tractor-removal of all boles > 20 inches (50 cm) diameter. Crowns and smaller boles were not utilised. The cleared areas were then planted largely to Acacia mangium with Eucalyptus grandis/urophylla at high elevations. From 1988-94 planting was suspended and there is now a backlog of c. 56 000 ha selectively logged but not planted. To date 11 000 ha of plantations have been created. The pulp mill requires c. 700 000 m^3 of wood per year, including fuel wood. Since 1995 10 000 m^3/month (c. 18 percent) has come from harvesting 50-60 ha/month of first rotation plantations. These are 7-8 years old. They have grown at 20-25 m^3/yr harvested volume and growth is markedly reduced on compacted soils. Planting has recently restarted on the 56 000 ha backlog.

Clearance contractors are now obliged to remove all stems ≥ 4in (10cm) diameter and SFI will accept material ≥ 2in (5cm) diameter. Technology for utilising crown wood is still not developed. Tractor extraction causes compaction to various degrees on 30-40 percent of the surface area. It is being progressively replaced with cable-yarding. By November 1995 there were 14 locally manufactured cable yarding machines with new ones being built at 2/month.

Nursery production of seedlings grown from selected seed is 5.2 million/year and is being expanded to 10 million. The ultimate aim is to plant 130 000 ha gross, or 80 000 ha net after leaving out slopes > 25°, village land, poor soil and catchments. The rate of new planting (in addition to replanting) should reach 15 000 ha/year by 1997. In 1994 1000 ha were planted and 3-4000 ha are expected in 1995.

After clear felling trash is piled and seedlings are planted at c. 3m spacing without burning. Three or more rounds of weeding are needed over the first two years before canopy closure. Mikania is a serious weed, but Merremia is absent and the bamboo Dinochloa is present but not a serious nuisance. It is planned to thin for pulpwood at 4 and 8 years and harvest at age 12. Acacia aulacocarpa and A.crassicarpa will furnish c. 20 percent sawlogs. A.mangium has hollow branches, gets stain and heartrot through these, and is not good for saw logs.

SFI encourages smallholder planting by villagers near its estate. It supplies seedlings and will buy the mature trees. So far c. 1 000 ha of A.mangium have been planted. SFI has submitted a proposal to the Sarawak Government to reforest non-productive waste land and Imperata grassland. These smallholder and Sarawak areas are largely Imperata fire climax grasslands on formerly forested land.

The SUAS project has taken place against this background and has had influence on current planting practice. Swedish involvement began with an environmental consultancy by the firm ÅF-IPK in 1986. Since 1987 the funds have come from SAREC and the third three year period ends July 1996. Professors H. Grip and N. Nykvist have been involved since the start and Dr A. Malmer since 1987. Malmer gets 60 percent of his salary from SAREC and has spent 2.5 of the past 9 years at Sipitang in a total of 10 visits. Most Swedish visits last a few weeks each. The main input has been on hydrology, soils, erosion and nutrients but in the early years sociology and entomology were included. (The discovery of an insect pest on Acacia mangium, although of potential economic significance, was not followed up despite a recommendation made at the time the grant was last renewed). There have been a few minor projects and short visits by students from Sweden.

1.2 First experiments, catchments W1-W6

These experiments and results so far have been fully described in numerous publications, of which 29 were read by this reviewer and are independently assessed by a second reviewer in Appendix 3. Here only an outline is included.

> These experiments form the main body of the SUAS input. Six small adjacent catchments of max. c. 11 ha area are included. All lie in hill dipterocarp forest. W1+2 is forest selectively felled then heavily damaged by the Great Fire of Borneo in 1983; A.mangium was planted after tractor clearance and burning. W3-W6 were all lightly selectively logged forest, not burned. No estimate (e.g. by counting stumps) has been made of harvesting intensity. W3 and W6 are the controls. W4 received minimum impact clearance (manual logging (so-called kuda-kuda), no burning) and W5 received normal SFI clearance (tractor logging, but only uphill, pre-planting burning). The yield was 60-100 m^3/ha pulpwood plus 20 t/ha saw logs. Both W4 and W5 were planted with A.mangium. There has been detailed and comprehensive measurement and monitoring of all catchments, starting in 1985 for one year before treatment in 1986, of hydrology, erosion, biomass and nutrients. Much, but not all, of the results to date have been analysed and published. The plantation on W1+2 was a failure: A.mangium grew very badly. This is ascribed to the double burn.

The most interesting and important result of these experiments is the contrast between low impact (W4) and normal (W5) preplanting clearance. It is clearly demonstrated that A.mangium grows much better on the low impact catchment and erosion and nutrient losses are much less severe. A summary of these and other key results is given in Table 1.

Table 1 **Main differences between minimum impact and normal clearance (W4 and W5)** (A Malmer pers. comm., see also numerous project publications)

		W4		W5
biomass of plantation at 3.8 y	-		-50%	
total planting cost ($M/ha)		1500		1700
soil disturbance area		4%		24%
soil infiltrability (mm/h)	15.4		0.1	
stream run off at 2 y (mm above 2000 mm control)		+500		+1200
stream siltation at 2 y (kg/ha)	2.2		4.9	
when		whole period from stream clearance		mainly after logging
undisturbed surfaces				
runoff		x3		x5
erosion at 1 y		x3		x5
composition		mineral soil		ash
dissolved nutrients in streams at 2 y				
N, P, K, Mg		-		double W4
Ca		both catchments similar		

Total nutrient loss via stream is c. 50 percent of loss by harvest except for K, for which it is > 100 percent

There is a mixture of acrisols and podsols, with clay-rich and sandy upper horizons respectively, and a range of intermediate soils in both W4 and W5. This has been discovered by successively more detailed soil mapping as the experiments have progressed. Fortunately the proportion of these soils in these two key catchments is roughly similar.

The plantations are reaching maturity and it is planned to fell them at 8.5-9 years age in April-May 1997 by the same means as before and then plant a second rotation tree crop. The normal extraction this time will be by cable- not tractor-yarding in order to match new SFI practice.

In early 1996 experiments to reverse soil compaction on tractor tracks by a range of scarification, mulching, and fertilisation treatments is due to be started. Work is also planned on nitrogen fixation, nutrient input from deep weathering, and possibly (with other SUAS expertise) on soil organic matter and dynamics of aluminium.

1.3 Second experiments, catchments W7-W11

Five new more or less contiguous catchments have been monitored since

May 1994 and treatments begun in 1995. All are in lightly selectively logged hill dipterocarp forest which was not burned in the 1983 Great Fire. This second group of experiments is designed to disentangle the different effects of soil compaction and burning in reducing Acacia mangium growth, which were confounded in the first experiment, and also to follow biomass and nutrient recovery in the forest fallow phase of shifting agriculture.

W8 is the control. The other four catchments have been clear felled for pulpwood using standard SFI tractor yarding. This involves much churning and compaction of the soil of c. 30 percent of the surface (area being measured December 1995). On W7 and W9 padi was planted in September 1995 without and with prior burning respectively. W10 and W11 form a second pair, not burned and burned respectively. On these, in addition to padi, A.mangium was planted in November 1995. A very detailed soil map on a 10 m grid with interpolation has been made. This reveals a fine mosaic of different soils. Within the two pairs the proportions of acrisols and podsols is similar, but there is a difference between the pairs which will weaken cross-comparison of results. The control soils are in a different proportion from either pair of treatments.

The burn was very incomplete. In November 1995 padi was growing poorly on the unburned sites, both within the burned treatments and the unburned ones. On the two unburned catchments many rice seeds have been eaten by rodents that hide in the unburned trash where raptors cannot see them. Rice that is planted on humus rather than mineral soil has poor germination. The whole experimental area is a long way from any other hill rice area and surrounded by lightly logged forest that was being cleared for planting in late 1995. Its isolation makes it highly vulnerable to pests and local wisdom is that rice cannot be successfully grown in a single small remote patch such as this. Nor is rice grown without prior burning.

1.4 Third experiment, Meligan grassland

During 1995 A.mangium seedlings have been planted into fire-climax Imperata grassland, in an area protected by a 200m wide firebreak, in the Meligan area which is a large enclave of village land in the southern part of the SFI concession. The focus is on soil improvement by the plantation. Above- and below-ground biomass and ecosystem nutrients were monitored in 1994 before planting and will continue to be monitored. This experiment, still in its early stages, was not visited by this reviewer.

B2 Analysis and assessment

This section addresses the series of questions posed in the Terms of Reference (Appendix 1).

2.1 SAREC administration

SAREC's three overall aims (see ToR Appendix 1) have been met, no important components have been omitted.

2.2 First experiments (W1-W6)

2.2.1 Scientific results. These experiments are good science in the judgement of both this reviewer and a second independent referee (see Appendix 3). The independent referee considers the work will come to be regarded as a classic

study in rain forest nutrient cycline, despite a number of criticisms of detail. They have resulted already in numerous publications in journals (some international and some refereed), books and conference proceedings, focused on different audiences. There is some repetition between these articles. The experiments begin to be well known in international professional and scientific circles and invitations are increasingly being received to conferences in order to talk about the project.

The true time series, following erosion, hydrology and nutrients before and after different treatments, are unique in tropical rain forest plantation ecology. The proposed study through a second rotation will also be unique. There are two main findings. Firstly, it has been shown that fire causes extra nutrient loss and lower plantation growth (A.mangium on the twice burned catchments W1+2 has grown worst of all). Secondly, minimum impact clearance (W4) is followed by better A.mangium growth than on areas receiving standard tractor clearance plus burning (W5). Unfortunately, the minimum clearance was manually, not by cable yarding, because the necessary machinery was not available. More seriously, W4 differs in two respects from W5: (a) minimum soil disturbance and little compaction plus (b) no burning. This means the relative importance of the two factors cannot be completely disentangled. (In fact there were two pulses of nutrient loss and erosion following clearance and burning respectively and the latter was much bigger (A.Malmer pers. comm.)). The results of these experiments have been fully taken up by SFI who now do not burn and are phasing out tractor clearance, but there has been little dissemination to the broader regional audiences of numerous plantation schemes in Indonesia and Malaysia. A third finding is that the plantation takes up a substantial fraction of total ecosystem calcium. This element is only present at very low concentrations in the soil at Sipitang and is virtually absent from rain so could become depleted by only a few harvests unless added as fertiliser.

A different project undertaken by SFI staff, funded by Japanese Trust Funds/World Bank (JTF/WB) and managed by FRIM, has taken place at Sipitang over several years since the SUAS project was started. Its aims were largely identical. Different results were obtained (A.Malmer pers. comm.). There has been virtually no contact. No publications have been seen, and it is suspected none were produced (A.Malmer pers. comm.).

Burning before planting is practised at the first rotation but not the second at Indah Kiat, Sumatra (M.Werren pers. comm. Nov. 1995) and by Sabah Softwoods to kill weed seeds, but not by Kolombangara Forest Products, Solomon Islands, who like SFI find it invigorates weed growth. No one beside SUAS/SFI seems to have conducted an experiment to see how tree growth is affected by a burn. There is clearly scope for publicising the SUAS/SFI experiment and stimulating its repetition elsewhere.

2.2.2 Capacity building. The project has been jointly between SUAS and SFI, about equally shared. SUAS, with SAREC funds, has equipped, maintained and up-dated two analytical laboratories at Mendalong and Sipitang. Some analyses are done at Umeå, fewer now than at first. Training has been given to laboratory staff including on two formal courses. One Sabahan has been funded for an Aberdeen M.Sc. Most training has been on the spot and has included all field aspects of the project. Back-up has been provided for the SFI Forestry and Wood Division staff. Since the project started SFI has lost 2 key staff through resignation. Late 1995 a new hydrologist and a new soil scientist will be appointed who it is intended to train on the spot by a short course in January 1996 and to bring to Umeå for another short course early in 1996. The analytical laboratories are essential to the efficient running of SFI, as are trained staff, and SFI is using SUAS to maintain both.

Malmer has worked on this project since soon after it started, and gained his Ph.D. from it. He is now on the staff of SUAS. The project has thus built capacity within Sweden.

2.2.3 Practical impact. The early results of these experiments have, as stated above, been extremely important to SFI and practice has been modified to utilise them. If long term nutrient depletion is detected by continued monitoring this knowledge will also be of extreme importance to SFI. Outside SFI the project remains little known and has had no impact in Sabah.

2.2.4 Regional aspects. The results are of potential significance for industrial tree plantations in the humid tropics (the JTF/WB results notwithstanding). There are extensive plantations already in the region and vast plans for the future. A strong case exists (see below) for SUAS to organise hands-on-training and demonstration courses to people at the appropriate level in the numerous bodies currently establishing these plantations.

2.3 Second experiments (W7-W11)

2.3.1 Scientific results and practical aspects. These experiments have only recently begun and do not yet have any results. The growth of padi in this situation has no parallel in the real world (see above):

(1) an isolated area of padi with natural forest nearby is likely to be eaten by pests either at planting or as it ripens;

(2) no one plants padi on forest land without prior burning to destroy the surface humus layer, release nutrients and destroy rodent havens;

(3) tractor clearance for pulpwood of all stems down to 25 cm diameter causes very extensive soil churning and compaction, it is only done on plantation concessions. In reality where farmers move into logged forest felling has been

for timber which removes only some of the big trees > (40)-50-60cm diameter with less extensive concomitant soil damage and much more of the biomass and above ground nutrients left behind.

The rice crop is likely to fail. If that happens these second experiments will:

(1) (W10/W11) follow growth of A.mangium after tractor clearance with and without burning. This will disentangle the two treatments confounded in W4/W5, and should confirm that burning is deleterious. The experiment has no immediate practical relevance to SFI who are rapidly moving to cable yarding in response to the earlier SUAS findings but will be an important demonstration to tree planters elsewhere who still use tractor extraction;

(2) (W7/W9) follow the recovery of biomass and nutrients in a clear-felled forest with and without burning (and with a (probably) failed padi crop). This too has no real world parallel as shifting agriculture (SHAG) does not take place on land totally cleared for tree plantations (and hence soil-compacted and substantially nutrient and biomass-depleted). It is true that there are very few studies following the recovery of above ground nutrients following SHAG, but this very special case reduces the relevance of the results.

2.3.2 Capacity building. These experiments will fill the role the first ones filled earlier.

2.4 Third experiment (Meligan)

2.4.1 Scientific results. No results have yet been obtained. There is planting of Acacia spp. into Imperata grasslands elsewhere in north Sabah by SAFODA at Bengkoka and also in Indonesia, notably the 140 000 ha Barito Pacific plantation on fairly fertile soils at Lampung, south Sumatra, and a Finnish-funded project near Banjermasin in southeast Kalimantan. No attempt seems to have been made to gain acquaintance of practice and findings of these earlier studies, nor to discuss in detail with ICRAF (Bogor office) their `alternatives to shifting agriculture' project.

2.4.2 Practical impact. There are huge areas of fire-climax grasslands, mainly Imperata-dominated in perhumid and slightly seasonal Malesia on areas once clothed in evergreen and semi evergreen rain forest respectively. These grasslands have little economic value. Local farmers around the SFI concession own large grasslands and SFI hopes to get planting areas in Sarawak, much of which will probably be Imperata-covered. It will therefore be valuable to know about nutrient and biomass aspects of plantations on these sites. It is uneconomic to haul pulp logs over c. 100 km by road to a pulp mill. Thus many grasslands will need to be planted for saw logs for which A.mangium is not suitable. It would be preferable therefore to have trials of other species, e.g.

A.aulacocarpa, A.crassicarpa, but this is a minor point of criticism.

2.5 Summary and conclusions

Excellent scientific results have been obtained with high relevance to important practical problems. The project is shared half and half between SUAS and SFI, and excellent rapport exists between SUAS and SFI staff at all levels. Thanks to the fax machine and Boeing/Airbus Industrie a project can now be closely monitored and conducted from half the world away. Experiments 1 are of international significance and are becoming well known, much more can be learned if they are continued through a second rotation. Experiments 2 are unfortunately unrealistic in several key respects (see above). They should, however, substantiate the findings of experiments 1. Experiment 3 might have benefited by prior investigation of other similar planting into grass. Essential training and support have been given, and continue to be given, to SFI in hydrology, erosion and nutrient studies, and SFI is dependent on this for its efficiency. One Swede has obtained a Ph.D. and a little extra capacity has been built in Sweden. (An attempt to fund a second Swede on soil studies failed early 1995 to obtain SIDA funds and has been abandoned, at least temporarily). There has been rather limited dissemination at a practical level in the region but good at international scientific level.

B3 The future

Catchment studies are inevitably long term in nature. SUAS has set these up in the anticipation of receiving further funding to see them to completion. A third three year phase would get experiments 1 into the second rotation, and see experiments 2 half way through the first rotation, (in confirmation of 1) as well a few years into forest recovery after unworldly clearance. Experiment 3 will be about one third way through a rotation. SFI undertake the routine monitoring of the catchments and SUAS is providing input for major aspects such as logging and replanting phases and overall SAREC input is pulsed and at a fairly low level. This could be a good model for the next phase. Does SAREC anticipate indefinite funding? Another agency might be found to fund some aspects because long term, rigorous paired catchment experiments such as these are rare and these are becoming justly famous. If SAREC pulled out now some of the kudos would fall to the new funder (e.g. European Union). SFI has a shifting set of commercially imperative questions and long term catchment studies may go onto the back burner without foreign input. But in the long run transfer to SFI has to be contemplated. During a next phase SUAS should explore possible local bodies who could in the long term provide SFI with the necessary back-stopping.

Current priorities for SFI are twofold. Firstly, how successfully to colonise grassland, and this is being addressed by experiment 3. Secondly, the c. 56 000 ha backlog waiting to be planted, plus the c. 11 000 ha already planted, have been tractor-cleared and have 30-40 percent of their soil surface variously compacted. It would be very valuable for SFI to know how to ameliorate

compacted sites, as even a 50 percent increase in the currently poor growth of A.mangium on them would be an important commercial gain (B.L.Sim pers. comm.). A small experiment is planned as part of group 1 to start in 1996. It is strongly recommended that this is given top priority, and more emphasis than at present. In this connection it is relevant that Indah Kiat in Sumatra propose to reverse soil compaction by using a tractor-mounted ripper from New Zealand (M.Werren pers. comm.)

There has so far been rather little dissemination of results at the practical level within the region. It is strongly recommended that full consultation is held with appropriate authorities and that regional workshops/seminars/ training demonstrations are held.

> SAREC has given funds to the Sabah Forestry Department for a seminar and this is now being planned by them for March 1996 (section A.3.2, above), but it will not include this project. (Within Malaysia it is not unusual for there to be little collaboration between different institutions, even those with overlapping or similar interests.)

SFI are said to regard the catchment experiments as good publicity and to have no objection to their being made more widely known and visited. A mechanism to do this would be to join the research panel set up early 1995 by the plantations division of CIFOR (section head J. Turnbull, co-ordinator C.Cossalter) that is investigating the long term sustainability of industrial tree plantations. Various Far Eastern organisations are involved and two meetings have been held so far. CIFOR (pers. comm. Nov. 1995) would welcome SUAS/SFI involvement.

Acknowledgements

This review would not have been possible without the willing collaboration and assistance of all members of the two teams from SUAS, staff at Yayasan Sabah and CIFOR, Dr. S.Appanah of FRIM, and Dr C.Marsh. Secretarial support was provided by ABW Associates. To all these people grateful thanks are offered.

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Appendix 1 Terms of reference (as revised 24 October 1995)

Appendix 1 Terms of reference (as revised 24 October 1995)

Terms of Reference for evaluation of the research cooperation between the Swedish University of Agricultural Sciences (SUAS), with the Malaysian Sabah Forest Industries (SFI), and Rakyat Berjaya (RBJ) of alternative methods of tropical rain forest management systems.

BACKGROUND

Sarec has financed research projects between Malaysia and Sweden on tropical forest management since 1987. The programme was initiated by a study of the effects of soil/nutrient losses after clear-felling of rainforest for forest plantations. In 1991, an additional research project on improved logging and silvicultural measures for forest management became included in the programme (that was initiated with SIDA funds a few years earlier). Both projects were extended in 1993 (as a follow up of UNCED). The first project was broadened to include forest restoration/reclamation of *Imperata* grasslands and a study of combining shifting cultivation rotation with fast growing *Acacia* plantations.

The objectives of the research programme are primarily result oriented. The goal is to increase the understanding of ecosystem responses to different forest management systems. Studies are aimed at minimizing the environmental impact, in combination with an increasing production on a sustainable basis.

Capacity building of Swedish foresters (for Ph.D-level) in Sweden were a second objective, and Malaysian forest engineers (for M.SC level at SUAS), became an additional objective of the programme in 1990.

SAREC's overall aims are to:
- help developing countries to build research capacity
- support research and transfer results which can help to solve important problems in developing countries
- promote scientific cooperation between Sweden and developing countries

The purpose of this review is to evaluate the Malaysian projects in the light of the above aims. The review shall cover the results, implementation, relevance, cost-effectivness and quality of both projects in the programme, in the light of the project descriptions and allocated budget. Additionally, an assessment of the future role/direction of the programme shall be made.

Specific issues to be considered:

1) SAREC administration
Have the projects been lacking important components for achieving the main SAREC objectives? If so, which?

2) Scientific results
Have the results contributed to new findings, given the present research frontier and compared with other scientific projects in the region?

- Evaluation of the results and the quality of current research projects in the light of other findings.
- Assessment of the quantity of the results/capacity developed.
- Have the results been obtained in the most cost-effective way?
- Dissemination of research results to concerned parties, SFI, RBJ, FD, or other projects, as in the scientific community in articles, workshops, training courses etc.

3) Capacity building
An evaluation of the scientific cooperation and the research capacity that has been built for the Swedish and the Malaysian and students/scientists.

- Are the different project activities carried out in a cost-effective way?
- The relevance of improving research facilities (laboratories, field stations), and their maintenance status now and in the future?
- Has other local scientists outside the collaborating parties participated in research activities? Is there any coordination with other research (and donor driven) projects in the region exists?

4) Practical impact of project results
What interest have the local government (on a policy level), or organisations like Sabah foundation, Inoprise Corporation SDN, in using the obtained results/ experiences.

- To what level have SFI and RBJ used results from the Sarec-supported research to improve their forest management?

5) Regional aspects
Are the results applicable elsewhere in the region, particularly for poorer countries with lower levels of Research & Development infrastructure ?

- Could the Malaysian research facilities and the Swedish/Malaysian scientists be utilized, e.g. if research training/courses in the region would be initiated.

6) Future research activities
What is the possible focus of the future research programme?

Report preparation and utilization

The final report should be maximum 50 pages, including an executive summary (max. 6 pages). Quantitative data or other important data may be added in appendices. The first draft of the report should be at the Sarec office, latest January 10, 1996.

The report may be used and distributed by Sida/Sarec in its entirity or in parts.

Timetable

A total of 4 weeks.
End of October: 3-4 days reading reports/papers of the conducted studies
Two weeks in November: field visits (to RBJ and SFI), and interviews with the scientists and other relevant organisation, and report writing
November/December 2-3 days for visiting the Dept. of Forest management and the involved scientists at Umeå, and if necessary SAREC in Stockholm.
December: preparing final report.

Suggestions of persons/institutes to interview/contact:

- SFI: Sipitang field area (contact person Sim Boon Liang), and/or Dr. Malmer
- RBJ: field area, Mr Awang Sahm Pulau, Dr. C. Marsh and Dr Falck/Hagner,
- FRIM, Dr. Appanah
- Sabah foundation
- Ministry of Natural Resources
- Forestry Department, (contact person Fredrik Kugan)
- CIFOR
- FORSPA, Bangkok
- Swedish scientists at Umeå (particularly those that were not in Malaysia in November), , Mr Cedergren, Prof. Nils Nyquist, Dr. Falck and Prof. Hagner, Dr Malmer

Appendix 2 Itinerary and persons met

1995

Weds Nov 1 dep. Cambridge 1500 BA33 LHR to Kuala Lumpur
Nov 2 arr. KL 1500, onward to Kota Kinabalu arr. 2030, Tanjong Aru Hotel
Nov 3 meet GM RBJ, **Awang Salim**; with **Francis Goh** to Tawau, Marco Polo Hotel
Nov 4 to Luasong (**Charles Garcia**, view nursery and research plots) and mile 41 logging camp Kalabakan. Meet Swedish team (**Hagner, Falck, Cedergren**)
Sun Nov 5 forest, expt. 2 lowland plots. Wet
Nov 6 forest, expt. 2 ridge plot. To Tawau overnight Marco Polo Hotel
Nov 7 to Sandakan. GTZ (**Michael Kleine**), Forest Dept. Planning Dept. (**Frederick Kugan**, on to KK. Night Tanjong Aru Hotel
Nov 8 breakfast **Cyril Pinso, Chan Hing Hon** (Inoprise Manager Forestry Upstream Div.). To Sipitang with **Malmer** and **Robert Apin**, meet **Nykvist**; pm meet **Alfred Jingulam** GM Forestry & Timber Div. SFI, briefing by **Sim Boon Liang**, Manager Research Plantations and R & D. Meet MD **Paul Cheng** at dinner
Nov 9 to Mendalong with **Malmer, Nykvist, Sim, Apin**. Inspect old experiment, catchments W1+2, W3, W4, W5; night Mendalong
Nov 10 New experiment, catchments W7,8,9,10,11; return Sipitang via village road; night Sipitang
Nov 11 To KK, Tanjong Aru Hotel. Drafting report
Sun Nov 12 Drafting report. Meet **Sutton** (Royal Society) and **Marsh**. 1550 to Kuala Lumpur Equatorial Hotel
Nov 13 FRIM, **Dr Razak**, Director, **Appanah**. Equatorial Hotel
Nov 14 To Jakarta, Le Meridien Hotel

Nov 24 Jakarta to Bogor, CIFOR (**Dykstra, Gillison, Turnbull, Cossalter**)

Dec 3 return to Cambridge

Dec 5 to London, night at airport
Dec 6 0710 to Stockholm, SIDA/SAREC (**Bruhn, Gerhardt**)
Dec 7 to Umeå, discussions (meet **Grip**)
Dec 8 discussions, to Cambridge, arr. 2300

Appendix 3 Review of hydrology and nutrient project publications by J.Proctor

The main part of this work is a rain forest catchment experiment in Sipitang, Sabah. This includes the water balance of control and treated catchments and losses of dissolved nutrients and those in sediments in the streamwater. The study has included: soil and biomass nutrients in the rain forest and Acacia mangium plantations, the erosion, surface run-off and changes of soil physical properties caused by disturbance, the nutrient losses associated with log removal, the growth monitoring of the plantation, and an economic analysis of the practice of burning in plantation forestry.

The work is of generally high quality and has been written up in a clear way although with considerable repetition in several of the papers. It is the best documented watershed study in tropical rain forest. The work has several novel features and has led to firm suggestions for improving the management of tropical plantations.

A number of critical points can be made however which the authors might consider in subsequent publications.

1 Some thoughts should be expressed about the lack of replication of the treatments particularly in view of the range of catchment sizes (3.4ha - 18.7ha) and their soil types. The terrain is not sufficiently well described for each catchment: were there important differences in slope between catchments? Can the results be extrapolated to flat areas in view of the fact that there are slopes of up to 57% in the plots and in the runoff plots the slopes were 19.6-42.8%?

2 Can the authors assure us, given the range of soils, that all the catchments were watertight?

3 The tractors seem to have been in the catchments at a wet time of the year. No consideration seems to have been given to dry- vs. wet-condition tractor logging in relation to damage to the forest.

4 There is no mention of attempt to quantify nutrient loss in dead plant matter such as leaves, twigs, litter and branches washed down the stream in floods.

5 There is a prevailing assumption that low nutrients are responsible for poor growth after forest disturbance. Yet soil compaction seems just as likely a cause of poor growth. Critical experiments - they need only be small scale - are needed to assess the true extent of nutrient limitations as opposed to that caused by other factors.

6 There is an assumption that because calcium is low in these Sabah soils then it is possibly limiting growth. This again needs careful experimentation, particularly in view of the fact that in some situations calcium is required only as a micronutrient. Nothing is known of the actual nutrient requirements of any of the trees and this point should be made clear.

7 Generalisations are made about plantation forests when only one species (Acacia mangium) has been tested. This nitrogen-fixing species is likely to have a nutrition that differs considerably from that of non-fixers and hence the results obtained using it need to be treated with caution in any extrapolations.

In spite of my criticisms I conclude that this is a good piece of work and the authors are to be congratulated upon it. It will be regarded as a classic study in the field of rain forest nutrient cycling.

Appendix 4.

Comments by Rakyat Berjaya SDN. BHD. on their project A: Silvicultural refinement of selective logging (executed by RBJ and SUAS, Department of Silviculture)

A 1.1, paragraph 3, line 4.

Comments: Yayasan Sabah operates just like any other forest concessionaire in Sabah. There is no special power delegated to it by the Forestry Department.

A 1.3, Last paragraph, whole paragraph

Comments: This statement implies the evaluator's lack of understanding regarding the role of YS in relation to FD. YS, as a logging concessionaire, is mainly concern with the extraction of timber from an area, based on guidelines provided by FD. In the process of extracting, it is governed by rules and regulations which are prepared entirely by FD. These guidelines are supposed to be the results of various research projects which FD is financed to carry out by the government. The various research projects are supposed to identify the best way (sustainable) of managing the forest, which is then imposed by FD to such concessionaire as YS. By function and responsibility YS is not required to carry out research, although it does so voluntarily.

A 2.1

Source of the sentence *'...and much of it several or up to seven times over.....'* needs to be properly verified.

A 2.1.2

Correction: At the time of the report (RIL I) only NEP (New England Power) is associated with the RIL project.

RIL is never officially associated with CIFOR. On operational level F.E. Putz was nominated as joint auditor on personal capacity and his association with Florida U. Dr Dennis Dykstra was invited by Dr Putz, which was welcomed by RBJ & NEP on personal grounds (line 21).

A 2.1.2, Paragraph 2

Correction: The extra costs associated with RIL are those activities which are not included in existing logging regulation. Examples of these are the climber cutting, stock mapping, skid trail, layout and marking for directional felling.

A 2.1.2, Paragraph 3

Correction: This paragraph is inaccurate. Our experience has shown that contractors do not see the financial advantage of RIL.

A 2.1.2, Paragraph 5

Correction: In an agreement signed in 1990 between FRIM and SFI, FRIM was appointed the Consultant to SFI, who was the recipient of the Japanese Grant Fund, administered by the International Bank for Construction and Development. The programme ran from 1990-1994 with a costing of approx. US$900,000.00 and comprises 3 major components, as follows:-

(1) Sustainable Management of Natural Forest
(2) Forest Plantation Development
(3) Rural Sociology

A 3.2, paragraph 9

Correction: Cedergren was never involved in the RIL project's experiment planning. Richard Taumas of RIL was involved in the directional felling courses only, and not the whole experiment with SUAS.

Comments by the Swedish research group (Dr. Jan Falck, Prof. Mats Hagner and Mr. Jonas Cedergren) on their project A: Silvicultural refinement of selective logging (executed by RBJ and SUAS, Department of Silviculture)

We have now read through the evaluation report, "Evaluation of the research cooperation between Sabah and the Swedish University of Agricultural Sciences on tropical rain forest management systems", by Professor T.C. Whitmore, Cambridge University. We wish to make a few brief comments.

We are impressed by his assessment of our project. Indeed he has pointed out qualities we were unaware of. There are however some points of mis-understanding and of differing opinions that we would like to bring attention to.

1. A comment on both of our is that they are experiments are rigorously designed and statistically controlled. That is of course most flattering. However, we feel that we have not gone to any extremes. Silvicultural research is complicated. The approach used by us is that normal in Swedish silvicultural research.

2. In the executive summary, paragraph 6 and 7, and on section A 3.2, paragraph 5, Professor Whitmore claims that the efficacy and cost effectiveness of low impact harvesting are already well known. We are less convinced than Professor Whitmore on the efficacy of low impact harvesting. True, there are numerous studies of ways to reduce logging damage (e.g. Jonkers & Mårn 1981, Appanah & Putz 1984, Chuah 1986, Hendrison 1991) However, more than that is needed to understand the long term impact of selective logging on the residual stand. What is needed is experimental studies with treatments replicated, including unlogged control plots, and with the forest described in detail before logging. Such studies are scarce. What has been shown by earlier studies is that damage to the residual stand can be reduced. Many of the earlier studies are unclear as to exactly how their low impact harvesting was done in the field. A major concern of ours has been to make sure that our methods are describable and readily replicable. Methods have been published, see appended list of publications.

To understand the long term effects of selective logging it is important that reactions of different species or groups thereof are followed over rather long periods. It may take years for some species to show response to through growth, retardation or mortality. Seemingly small tree injuries may prove fatal after a number of years. Merely static measures of damage levels are not sufficient to investigate these issues.

Further, we have not yet encountered any reports where it has been convincingly shown that low impact harvesting is more cost effective than normal practise. An educated guess based on our experience and earlier studies (e.g. Jonkers & Mårn 1981, Chuah 1986 and Hendrison 1991) would be that differences are modest. Comparative studies of harvesting systems at operational level are major research undertakings. We have, in a modest scale started work on this issue. A fresh graduate, with particular skills in work and time studies, has made a Minor Field Study with YS to set up develop methodologies and train YS staff in this area. The report (Andersson 1995) reached us only a few days ago.

3. In the executive summary, paragraph 6 and 7, Professor Whitmore claims that climber cutting is known not to be cost effective.

We do not quite agree on that. Evidence on the effects of the treatment on felling damage from earlier studies is contradictory (Fox 1968, Liew 1973, Appanah & Putz 1983). Certainly, climber cutting carried out as a blanket treatment using jungle knives (*parangs*) is tedious and hard work, and therefore expensive (cf Liew 1973). For that reason we have tried using brush axes and small chainsaws as a complement to the parang. We have made no scientific evaluation of this, but the rise in labour productivity was obvious. Should our results indicate that climber cutting is an effective treatment in improving the residual stand, research into improved methods of carrying out climber cutting would seem justified. Another aspect of climber cutting is that it improves work safety for fellers, as fewer big climbers would be falling from the tree crowns, confirmed by interviews with local fellers. Felling trees in forests like those of Sabah is an extremely dangerous work (cf Jonsson & Lindgren 1990).

4. There seems to be some misunderstanding regarding the standards required for an M.Sc. degree at our University, Section A 3.2, last paragraph. Probably, blame is more on us than on Professor Whitmore. Our university allows for flexibility regarding the balance between courses and thesis work. Together with senior RBJ staff we have agreed on the need to train personnell in permanent plot procedures and planning of harvesting. Therefore, Andrew Garcia and Francis Goh have undergone an extensive programme of courses, a substantial part of which has been done in the field under daily supervision of Dr. Jan Falck and Professor Mats Hagner. True, the programme they have gone through is probably different from a purely research oriented programme in UK. Needless to say, all standards stipulated by Swedish research training policy on for M.Sc. programmes have been observed. We are indeed proud of our M.Sc. graduates.

5. Concern on section A 3.4, regarding applicability of our results outside

Sabah is justified. There is no reason to believe that permanent plot procedures, felling techniques and methods of skid trail alignment should be inapplicable elsewhere in the tropics. Modifications may be necessary, but hardly to any major extent. Issues dealt with beyond pure methodologies are of general interest. They include e.g. how much volume can be extracted per unit area if yields are to be sustainable, how can the present diameter limit felling system be improved upon, and what qualities of residual stands will be required if sustainable yield is to be achieved. Conditions in the tropics vary considerably, and our results should certainly be viewed with caution outside Sabah. We are however confident that our results will contribute to development of silvicultural principles that will be of general value.

As forest industries develop outside SE Asia, extraction rates are likely to increase (Ewel & Conde 1980). This will further increase validity of our results.

6. Professor Whitmore, in the executive summary paragraph 10 and section A 4.2, first paragraph, stresses the need for a focus on logged over forests in our future research. We agree. In fact Experiment 2 deals with the development of logged over forest. Experiment 2 has unlogged control plots. They are included only to improve our understanding of processes in the logged plots. Tropical areas often offer the possibility of including primary forest in silvicultural research. Whenever a forest subjected to treatment, be it logging, slash and burn or purely silvicultural treatments, natural processes to make the forest return a natural state commence. Therefore it is of value to know what the forest was like in its primary state, an opportunity since long sadly lost in Swedish forests.

We do not propose to work with primary forest only in our future work. We would however like to include a component of primary forest in a future study, as a control and tool in understanding the development of logged over forests and in evaluating treatments. That would increase the general applicability of our results. In short, we need a component of primary forest to improve our work on secondary forest.

7. We agree with Professor Whitmore that we need to be better established in the tropical rain forest management "network". However, keep in mind that we do not have a 30-year background in the tropics, and that we have until quite recently been fully occupied by harvesting operations and plot establishment. We have nevertheless cooperated with the NEES-RIL project, and as part of that we have developed contacts with CIFOR. Our relationship to FRIM is excellent, and we hope to start a more regular cooperation.

Some of our publications have been rather widely disseminated. Cedergren et al 1994 which describes the harvesting system adopted for Experiment 2 has aroused attention from various corners of the world. Cedergren et al, 1995 was presented at the IUFRO conference in Tammerfors last summer. Cedergren et al, 1996 will be presented at the SAREC sponsored conference in Sandakan next week. The manual for directional felling (Klasson & Cedergren 1995) has aroused considerable international interest. Four articles (concerning Experiment 1) will be submitted to scientific journals shortly. A complete list of publications will be sent to SAREC shortly.

8. Finally we were pleased to note Professor Whitmore´s positive comments on our rapport with YS staff. They are very qualified and a pure pleasure to cooperate with. Their input in our project cannot be overrated. We were further pleased to note on page 20 that Professor Whitmore suggests an element of core funding to our project. That would be much appreciated.

These were our comments. We regret if the tone might be a trifle sore, as we agree on most of Professor Whitmore´s comments. It was most rewarding to spend time in the forest and in the office together with somebody as knowledgeable as Professor Whitmore.

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Comments by the Swedish research group (Dr. A. Malmer and Dr H. Grip) on their project B: Hydrology and nutrients on conversion to plantations between (executed by SFI and SUAS, Department of Forest Ecology.

B 2.3.1 Scientific results and practical aspects (W7-W11).

"The growth of padi in this situation has no parallel in the real world.": This is true, and the padi is presently preforming less well without burning, but it was also true for the previous experiment of planting forest plantation without burning. Hence, with the previous experiment in mind, we felt it was highly desirable to also include treatments without burning. This will give us the full picture of the performance of both trees and padi, and makes the layout more comparable to the previous experiment. Furthermore, the new experimental layout in W7-W11 further resolves the effect of avoiding burning, but still using tractors, which was not included as a treatment in the previous experiment.

(3): The volumes (and nutrient) extracted from the clear-felling in W7-W11 are not so severe as described (compare correction above). 25 cm is the minimum diameter extracted at a clear-felling operation. Furthermore, many larger stems are also left behind because of cracked or crooked wood and unsuitable species for pulp. At the clear-felling in W4 and W5 the extracted wood were only 40 - 50 % of the volume available larger than 25 cm diameter. (SFI have presently invested in a chipper for smaller diameters at the mill , but smaller wood is still not extracted due to difficulties in transport of smaller and crooked wood.)

"Little contact with regional bodies" B 2.2.1, paragraph 2 and B3.

It is true that our findings need more publicity and spread regionally, especially towards the forest industry, but the picture of "...virtually no contact..." is a little harsh.

There has not been any final and common evaluation of the "Japanese funded experiments" in Sipitang, supervised by researchers from FRIM. However, it was the same research officers at SFI who worked with both the Sarec and the Japanese experiments, and researchers from FRIM have also visited W1-W6 together with Swedish researchers at the time for setting up the Japanese experiments. Furthermore, Anders Malmer have spent substantial time at visits in Sabah, discussing results from the Japanese experiments with SFI officers, and helped with supplying some sampling equipment from

Sweden.

As to other research contacts in the region, Swedish researchers have participated at local Sabah seminars etc. in 1986, 1988, 1990 and 1991, and SFI officers have continuous relations with Sabah Forest Department, UKM university in K.K. and the Sabah Foundation. Furthermore, Swedish researchers have visited FRIM at a number of occasions, as well as met with FRIM researchers at a number of regional and international meetings since 1986. Journal of tropical Forest Science (FRIM' s scientific journal) has published one paper from the Mendolong project in 1991 and another one is in press 1996.

Another important aspect on the spread of information in the region, is that people in contact with our joint project, active in SFI, transfer to other companies in the region. One example is SFI's former soil officer Peter Wong. He gained a MSc within the project and have been continuously trained for more than 10 years. He has now taken up a post as Research Manager at Indah Kiat in Indonesia. He is lost as a resource for SFI, but his training with the project will make an impact on the largest forest plantation establishing company in the region.

"...not requiring much SUAS input..." Executive summary 16 and 20, B3 The future.

Indeed, the intensive monitoring of W7-W11 is just over, which means that some sampling will go down to a lower level. However, it is important to know that even a low continued monitoring of 11 catchments with different treatments still requires a substantial field and laboratory staff and soil and water analysis both in Sabah and in Sweden, as well as officers for proper scientific supervision of continuous work and evaluation of data.

Presently, both involved research officer positions at SFI (soil and hydrology) are vacant and will be taken up by new staff. In view of this, the SUAS input with continued supervision can not be expected to decrease fast. Also, in view of these vacancies during 1994 and 1995, the backlog of unprocessed data is presently even larger than in 1993, at the last renewal of funding from Sarec. SUAS tried to make data processing and supervision more effective by appointing another Swedish research assistant with the project during 1994 and 1995. However, as Sarec turned down funding for a Swedish PhD student within the project, SUAS had to abandon this strategy in November 1995, after temporary financing of the candidate for almost one year (cf. evaluation B 2.5).

For Swedish resource building, Anders Malmer has gained a PhD within the project, and is presently holding a 40 % post as

teacher at SUAS. However, like stated for the other SUAS project (A Section 4.4), the continuity of this expertise is still dependant on the periodic renewal of contracts, and is lacking core funding.

Consequently, even with a lower degree of monitoring, and especially if competence build up in SFI is desired to take over full responsibility in the future, there is a very significant need for more input from SUAS. This need is both for a continued researcher/research leader position as well as a research assistant.

Additional review on hydrology and nutrients, by John Proctor.

The critical points 1 - 7 reflects well the general questions that so far have been of major discussion at the scientific presentations from the project for the last 10 years. In general these issues are acknowledged by us. Some will be able to solve in the continued work, while some require more detailed (even more extensive) experiments and more process oriented research, which have previously not the been in the highest priority of funding from Sarec and SFI.

In short, comments to a few of the points will be given:

2) The question of watertight catchments is essential, and have beenaddressed previously, most extensively by Malmer (1992).

3) The extraction of wood from W4 and W5 was made at a" wet period"of the year. This was according to "normal practise" due to that there are no restrictions to times of extraction in the area, as there are no regular dry periods. However, during the most rainy days extraction is normally stopped (Malmer and Grip, 1990).

4) Attempts to sample floating load was made (Malmer. 1993), but it seems as most organic material transported by the streams occurs as small particles in suspended load (Malmer, in press). This is well according to the view that leaves, wood and bark falling into the river will be trapped rather quickly and transform to smaller particles by disintegration and decomposition before continued trans port downstream (cf. Spencer et al., 1990).

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Comments by Sabah Forest Industries SDN BHD. on their project B: Hydrology and nutrients on conversion to plantations (SFI and SUAS, Department of Forest Ecology).

Section B 2.3.1. 'planting of padi without burning is unrealistic'

The common practise is to burn and then plant the padi, but the experiment is trying to find whether planting can be done without burning, comparing the cost and benefit with the traditional burn and plant method. If padi can be planted without burning this will reduce the environmental pollution and erosion caused by burning.

Section B3 paragraph 3. 'So far little dissemination of results within the region'

This is not really true. In April 1990 SFI hosted a 2 days seminar on this project. It was attended by 20 participants, 10 from SFI (staff from Management, Production, Plantation and Agroforestry Department), 3 from SUAS, 1 from Yayasan Sabah, 2 from the Ministry of Environment and 3 from the Forest Department.

The results of the project are also compiled in the SFI Annual Report for R & D. Copies were sent to FRIM and Forest Department.

Part of the results were published in Journal of Tropical Science, published by FRIM, Kuala Lumpur.

The trail was visited at various occasions by staff from FRIM, FRC Sabah and university students.

The results of the project has been repeatedly presented in several local seminars/workshops. The most recent one is the Marketing Conference on Pulp & Paper held in Kundasang hotel, Sabah in April 1995, hosted by SFI.

Section B 2.2.1, paragraph 3. Regarding the JTF/World Bank project 'there has been virtually no contact , no publications have been seen'

A copy of the reports (internal and final reports) of that project has been given to our counterparts from SUAS. Also the SFI staff doing the JTF project are the same doing the SFI-SAREC project. The statement is therefore not true.

Sida Evaluations - 1995/96

95/1 Educação Ambiental em Moçambique. Kajsa Pehrsson
Department for Democracy and Social Development

95/2 Agitators, Incubators, Advisers - What Roles for the EPUs? Joel Samoff
Department for Research Cooperation

95/3 Swedish African Museum Programme (SAMP). Leo Kenny, Beata Kasale
Department for Democracy and Social Development

95/4 Evaluation of the Establishing of the Bank of Namibia 1990-1995. Jon A. Solheim, Peter Winai
Department for Democracy and Social Development

96/1 The Beira-Gothenburg Twinning Programme. Arne Heileman, Lennart Peck
The report is also available in Portuguese
Department for Democracy and Social Development

96/2 Debt Management. (Kenya) Kari Nars
Department for Democracy and Social Development

96/3 Telecommunications - A Swedish Contribution to Development. Lars Rylander, Ulf Rundin et al
Department for Infrastructure and Economic Cooperation

96/4 Biotechnology Project: Applied Biocatalysis. Karl Schügerl
Department for Research Cooperation

96/5 Democratic Development and Human Rights in Ethiopia. Christian Åhlund
Department for East and West Africa

96/6 Estruturação do Sistema Nacional de Gestão de Recursos Humanos. Júlio Nabais, Eva-Marie Skogsberg, Louise Helling
Department for Democracy and Social Development

96/7 Avaliação do Apoio Sueco ao Sector da Educação na Guiné Bissau 1992-1996. Marcella Ballara, Sinesio Bacchetto, Ahmed Dawelbeit, Julieta M Barbosa, Börje Wallberg
Department for Democracy and Social Development

96/8 Konvertering av rysk militärindustri. Maria Lindqvist, Göran Reitberger, Börje Svensson
Department for Central and Eastern Europe

96/9 Building Research Capacity in Ethiopia. E W Thulstrup, M Fekadu, A Negewo
Department for Research Cooperation

96/10 Rural village water supply programme - Botswana. Jan Valdelin, David Browne, Elsie Alexander, Kristina Boman, Marie Grönvall, Imelda Molokomme, Gunnar Settergren
Department for Natural Resources and the Environment

96/11 UNICEF's programme for water and sanitation in central America - Facing new challenges and opportunities. Jan Valdelin, Charlotta Adelstål, Ron Sawyer, Rosa Núnes, Xiomara del Torres, Daniel Gubler
Department for Natural Resources and the Environment

96/12 Cooperative Environment Programme - Asian Institute of Technology/Sida, 1993-1996. Thomas Malmqvist, Börje Wallberg
Department for Democracy and Social Development

96/13 Forest Sector Development Programme - Lithuania-Sweden. Mårten Bendz
Department for Central and Eastern Europe

96/14 Twinning Progammes With Local Authorities in Poland, Estonia, Latvia and Lithuania.
Håkan Falk, Börje Wallberg
Department for Central and Eastern Europe

96/15 Swedish Support to the Forestry Sector in Latvia. Kurt Boström
Department for Central and Eastern Europe

96/16 Swedish Support to Botswana Railways. Brian Green, Peter Law
Department for Infrastructure and Economic Cooperation

96/17 Cooperation between the Swedish County Administration Boards and the Baltic Countries.
Lennart C G Almqvist
Department for Central and Eastern Europe

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