Application of the STREK Permanent Sample Plot Database for Management Purposes:

Opportunities and Challenges.

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Executive Summary

This document reports on the results of initial data analysis and modelling activities utilising data from the permanent sample plots developed by the STREK project in the Labanan Concession of PT Inhutani I, Tanjung Redeb, East Kalimantan.

The design of the STREK experiment is reviewed and the significance of the resulting datais discussed in terms of potential use in the management of the Labanan concession of PT Inhutani I, and for Indonesian Forestry in general. It is concluded that the sample plots represent one of the most significant sources of information for growth and yield studies in Indonesia.

The STREK data were subjected to preliminary statistical analysis to illustrate potential application for management.

Results from the thinning trial demonstrated that differences existing between plots before the treatments were applied complicate the interpretation of results. For this reason it is suggested that the analysis should concentrate on quantifying processes leading to changes in the standing stock of the forest.

Similar difficulties are likely in the interpretation of the logging experiment. It is proposed that both trials should be analysed to quantify the changes in basal area and volume with time resulting from growth, recruitment, natural mortality and mortality resulting from silvicultural treatments or harvesting. It is concluded that changes in total stand volume may be misleading for purposes of forest management, and it is suggested that future analysis should report the changes in commercial volume above the current diameter cutting limit.

Analysis of diameter increments in the logging experiment produced mean annual increments of up to 0.77 cm^{-1} in commercial species. There was no evidence in the data for individual tree increments to be 1 cm yr^{-1} as often assumed in Indonesian forestry. Diameter increments of up to 4.5 cm yr^{-1} were observed for pioneer species.

It was concluded that the statistical analysis of the STREK data will need to be combined with a range of modelling approaches to make the data available for forest management. A number of models were discussed including the BFMP Yield Simulation System, the GTZ DIPSIM model and the DFID SYMFOR model.

A sample application of the $SYMFOR^{99}$ model was used to demonstrate how models could be used to make forward projections of standing stock. The model was used to compare the predicted results from the STREK logging trial. Data from the conventional logging treatment was compared with a reduced impact treatment. The model predicted that at the end of a 35 year cutting cycle, that there would be sufficient commercial volume to support harvesting. It was observed, however, that the majority of the volume resulted from large trees that had not been harvested at the first harvest.

The model suggested that the plots with reduced impact logging were likely to have a higher increment of commercial volume compared with the conventional logging treatment. The commercial increment for the RIL plots was estimated to be 0.65 m^3 yr^{-1} compared with 0.41 m^3 yr^{-1} for the conventional logged plots.

The development of an integrated yield scheduling system for the Labanan concession is discussed. It is concluded that growth and yield models need to be integrated with the BFMP environmental framework, inventory and permanent sample plot data. This system will need to include modules to simulate harvesting strategies and the results from changes in land use.

It is suggested that the development of a yield scheduling system for sustainable management of the Labanan concession will require the development of clear short, medium and long-term management objectives for the area. These will need to address objectives for forest production, environmental protection and interactions with the local communities.

The analysis of the STREK database identified a number of data management issues. These are discussed and suggested changes recommended. The analysis also identified a number of minor errors in the database. These have been documented and work in now in progress to rectify any problems before the next version of the database is released which will contain the latest data from the fifth measurement campaign.

Recommendations.

1. The results from the STREK trials need to be subjected to more detailed statistical analysis in order to apply the results to improve forest management. This analysis should be undertaken when data from measurement campaign five are available in the second quarter of 1999.
   (3.1.2)

2. The results from the STREK thinning trial need to be analysed to derive the total basal area removed by thinning to establish why there was an apparently small reduction in basal area following logging.
   (3.2.5)

3. Statistical analysis of the STREK logging trial needs to be combined with modelling approaches to make these results directly applicable to current forest management and logging practice.
   (3.3.6)

4. Data analysis from the STREK plots should quantify the total amount and changes in commercial volume, represented as trees of commercial species that exceed the diameter cutting limit.
   (3.4.2)

5. Statistical analysis of the silvicultural treatments in the STREK trials should quantify the net changes in basal area and volume as functions of growth, mortality and recruitment and the effects of stem removal by logging or thinning.
   (3.4.3)

6. The implementation of a yield scheduling system for the Labanan concession will require the integration of PSP and inventory data with the GIS environmental framework and statistical and modelling analysis.
   (4.1.1, 4.5.1)

7. The BFMP yield simulation system should be re-run when revised data from the STREK plots and BFMP inventory are available for model calibration and initialisation.
   (4.2.3)

8. The possible application of the DIPSIM simulation model to assess the annual allowable cut using the BFMP inventory for the Labanan concession should be investigated in conjunction with GTZ staff.
   (4.3.2)

9. Methods to apply SYMFOR to the BFMP inventory should be investigated. One approach would be to establish new one-hectare sample plots in conjunction with the inventory. Another would involve deriving artificial plot data from the existing inventory.
   (4.4.1)

10. The assessment of a sustainable cut for the Labanan concession should be defined in terms of acceptable changes in stand volume (stocking) and net commercial volume increment.
    (4.4.6)

11. The SYMFOR model should evaluate the possible benefits of including indices of the local environment, including topography and slope position. The generation of suitable descriptors for the STREK plots should be investigated using direct analytical and indirect visualisation techniques.

(4.4.8, 4.5.4)

12. The BFMP project should assist Inhutani to establish and document short (1 year) medium (5 year) and long-term (35 year) objectives for the management of the Labanan concession.

(5.1.1)

13. The table and database structure of the BFMP STREK database should be modified to be compatible with the existing design of BPK-Samarinda's Growth and Yield Data System (GYDS)

(6.2.1)

14. The assignment of codes for new species for use in the STREK database should be corrected to be consistent with those defined in the master species database of the GYDS. These should be linked to those used for the BFMP inventory system

(6.2.4)

15. The volume equations used for the STREK database should be checked against original data sources.

(6.2.5)

16. The structure of the STREK database should be modified so that volume equations are contained in a separate table, linked through a relation to the species table. The volume equation table could be the same as will be used for the BFMP inventory database.

(6.2.6)

17. The documentation of the Growth and Yield Data System (GYDS) needs to be updated by BPK-Samarinda for both the structure of the database and data processing and validation procedures.

(6.3.1)

18. Full documentation is required for the data entry system for the BFMP STREK database. This should include the structure of the relevant database tables, and procedures for validation and integration of the resulting data into the master copy of the STREK database.

(6.3.2)

19. Changes to the STREK database structure should be reviewed, agreed and fully documented.

(6.3.3)

20. Modifications and corrections to data contained within the STREK database should be documented as part of the update procedure.

(6.3.3)

21. Sources of all information in the STREK database should be documented.

(6.4.2)

22. Full documentation should be produced for the procedures used to obtain check and process information contained in the STREK database. This should be annotated to show when and how procedures have changed during the project.

(6.4.3)

23. The master copy of the STREK database should be maintained by BPK Samarinda with a working copy at Tanjung Redeb and duplicate copy in Jakarta.

(6.4.4)

24. Regular backups should be created of the master STREK database and working copy at Tanjung Redeb. A non-volatile copy should be stored on CD-ROM to form an archive documenting changes to the database.

(6.4.5)

25. Procedures need to be developed and implemented to approve and document changes to the structure or data of the STREK database.

(6.4.6)

26. Errors in the STREK database should be corrected before the campaign 5 data are released.

(6.5.1)

Abbreviations.

AAC	Annual Allowable Cut
BFMP	Berau Forest Management Project
BPK-S	Balai Penelitian Kehutanan, Samarinda (Forest Research Institute), Samarinda
DBH	Diameter at Breast Height (1.3 m)
DFID	Department for International Development (United Kingdom)
Ditjen PH	Directorate General for Forest Production, Ministry of Forestry and Estate Crops.
DIPSIM	Dipterocarp Simulations Model (GTZ,Growth Model)
GIS	Geographic Information System
GTZ	Deutsche Gessellschaft fur Technische Zusammernarbeit. (Germany)
GYDS	Growth and Yield Data System
ITCI	International Timber Corporation Indonesia (Forest concession, East Kalimantan)
NFI	National Forest Inventory
PCT	Potential Crop Trees (Thinning treatment)
PH	Directorate General for Forest Production, Ministry of Forestry and Estate Crops.
PSP	Permanent Sample Plot
RIL	Reduced Impact Logging
RKL	Five year operating plan.
SFMP	Promotion of Sustainable Forest Management systems in East Kalimantan, (GTZ)
STREK	Silvicultural Treatments for Regeneration of logged over forest in East Kalimantan.
SYMFOR	Sustainable Yield Management for Tropical Forests. (DFID, Growth model)
TPTI	Indonesian Selective Logging and Replanting System
YSS	Yield Simulation System (BFMP growth model)

1 Introduction

1.1.1 This document reports on the results of initial data analysis and modelling activities utilising data from the permanent sample plots developed by the STREK project in the Labanan Concession of PT Inhutani I, Tanjung Redeb, East Kalimantan.

1.1.2 The report describes the nature of the data and potential uses to support the development of improved or sustainable forest management in the region. The report is divided into sections considering:

- Description of the STREK plots.
- Statistical analysis of PSP data.
- Modelling analysis using PSP data.
- Objectives for sustainable forest management.
- Data management issues relating to the STREK database.

1.1.3 The main purpose of this report is to identify and illustrate opportunities to apply these data to improve forest management. The report then suggests activities that are required to achieve this objective and make a number of recommendations required to support this work.

1.1.4 Analysis of the STREK PSP data identified a number of issues relating to data management. These are discussed in the final section of the report which recommends ways to improve data management to enhance the value of the data, making it more readily and reliably available for analysis and management purposes.

2 The STREK Plots.

2.1 Introduction

2.1.1 The STREK project (Silvicultural Techniques for the Regeneration of logged-over forest in East Kalimantan) established 72 hectare of permanent sample plots during 1990 and 1991. These plots were distributed in two types of forest in the concession on Inhutani I. Each sample plot is 4 ha square. Six plots (24 ha) were established in an area of logged-over forest (RKL-1) that had been logged in 1979/80. Another 12 plots (48 ha) were established in an adjacent area of unlogged forest (RKL-4).

2.1.2 Once established the plots were utilised to monitor the effects of a range of silvicultural treatments for Dipterocarp forest. The plots in RKL-1 were used in a trial to quantify the benefits of thinning treatments in logged-over forest. Those in RKL-4 were used to compare the effects of conventional and reduced-impact logging techniques on the regeneration of the stand.

2.2 Experimental treatments and data collection

2.2.1 Each four hectare plot was surveyed at the start of the experiment, recording details of every tree within the plot with a diameter exceeding 10 cm, a total of over 13,000 records. For each tree, the data recorded included diameter, species and a description of the crown. Tree species were recorded using botanical naming, with the majority of trees now identified to species level. Tree measurements have been repeated at regular intervals of two-years in order to monitor the growth and yield of the forest stand following the logging and silvicultural treatments. The BFMP has continued these measurements and will complete the fifth campaign of measurements by March 1999.

2.2.2 The experimental treatments in RKL-1 compared the growth of untreated logged-over forest with two thinning treatments. A systematic treatment was applied to two plots, where all non-commercial trees above a diameter limit of 20 or 30 cm were removed by poisoning. The second treatment was used to remove competing trees surrounding selected potential crop trees (PCT). In RKL-4 conventional logging techniques were compared with reduce-impact techniques using either a 50 or 60 cm diameter cutting limit. Data from the sample plots were analysed by the STREK project in order to describe the initial effects of the experimental treatments (up to the end of 1995), a period of four years following logging.

2.2.3 It is the nature of growth and yield studies that the true value of the data resource increases as the length of the measurement record increases to extend beyond the initial period immediately following logging. Now that the BFMP will complete the fourth and fifth measurement campaigns covering a period of eight years, the value of the data for forest management and research has significantly increased. The data from the STREK plots are now being used in a comprehensive analysis by BFMP and Inhutani staff of the longer-term benefits of the experimental treatments. The data are also playing an essential part in the development of a number of predictive models of forest growth and yield for Indonesian forestry management. The value of the data for these applications will continue to increase as more measurement campaigns are completed.

2.3 The STREK plots in the Indonesian and International perspective.

2.3.1 The STREK plots represent one of the most valuable data resources for growth and yield studies in Indonesia. They are significant for the following reasons, the large area (72 ha), comprehensive botanical identification and range of experimental treatments. There are two other sets of comparable plots in Kalimantan. PT ITCI established 14 plots covering a total area of 11.5 ha during 1976/77 in mainly logged-over forest. These plots have been measured at irregular intervals since then with ten measurement campaigns completed. The ITCI plots do not include any silvicultural treatments. More recently, a series of 15 plots was established by BPK-Samarinda with the UK-DFID covering an area of 15 ha. Six of these plots were logged in 1997/98 using reduced impact logging techniques. The first post-logging measurement will be completed in 1999, and as such the data do not yet cover a significant period for growth and yield studies.

2.3.2 The STREK plots retain their significance in the international context. There are a number of sets of plots in similar forest types in Peninsular Malaysia, Sarawak and Sabah. These often cover a longer time period and may have equivalent or larger areal coverage. Some, however, were implemented in unlogged forest (e.g. Danum Valley in Sabah) and others in logged-forest with no equivalent unlogged controls.

2.3.3 The STREK plots are significant nationally and internationally for the following reasons:

- Area of plots (72 ha).
- Experimental treatments (2 thinning and 3 logging treatments).
- Botanical identification.
- Tree position recorded (important for some modelling activities).
- Data quality

3 Statistical analysis of the STREK data

3.1 Introduction

3.1.1 Data from the STREK permanent sample plots represent a very valuable but unrealised resource to support management of forest resources in the Inhutani I Labanan concession and elsewhere in Indonesia. Preliminary results from analysis of some of these data are presented in this report to illustrate the current and future value of the trials.

3.1.2 The preliminary analysis illustrates that much more detailed statistical analysis is required in order to interpret the results in a way that can be applied to improve forest management. This should be extended and completed as soon as the data from measurement campaign five become available in the second quarter of 1999.

3.2 STREK thinning trial

3.2.1 The thinning trial consists of three treatments, an untreated control, systematic thinning and thinning to release potential crop trees. Each treatment was applied to 8 hectares of forest in two replicate plots. Data from the first four measurement campaigns are presented as Fig. 1 summarising the changes in total stem number, basal area and volume.

3.2.2 The data show that there were significant differences between the plots selected for the three treatments. Of most importance is the observation that the control plots had significantly fewer trees, total basal area and volume per hectare. The plots selected for systematic thinning were intermediate to the control and PCT plots. The differences between the plots will need to be taken into account when the results from the trial are interpreted.

3.2.3 The largest reduction in stem numbers, basal area and volume was observed between campaigns two and three (Fig. 1). After the thinning treatment, there was no significant difference in the mean total basal area and volume of all three treatments. Ideally, the thinned treatments should have been lower than the control, but the effect of the thinning was to reduce the values for these plots down to a level similar to that of the untreated controls.

3.2.4 The original design of the thinning trial (Sist & Abdurachman, 1998a) stated that the optimal thinning regime should remove up to 35 % of the total basal area of the stand. The treatments were implemented with a target removal rate of up to 30 %. The results show, however, that there was a much smaller reduction in basal area observed two years after the application of the thinning treatments. The reduction in basal area in the systematic treatment was from 25.8 to 23.1 m^2 ha^{-1}, a 10 % reduction. The potential crop tree treatment removed 12 % of the total basal area with a reduction from 28.1 to 24.8 m^2 ha^{-1}.

3.2.5 The reason for the apparently small reduction in total basal area following thinning cannot be determined from this simple analysis. There are two possible reasons, firstly that the poisoning treatment had a low success rate. The initial analysis of the data conducted by the STREK project suggested that the poisoning had a high success rate (Sist & Abdurachman, 1998a). An alternative explanation would be that there was rapid growth of other trees after the poisoned trees died. These results need to be examined in detail to consider which of these alternatives is more likely. This can be tested by quantifying the total basal area removed by poisoning between campaigns two and three.

3.2.6 The mean total basal area and volume increased in all treatments between campaigns three and four. These results need to be analysed to determine and compare the net commercial volume increment when data are available from measurement campaign five.

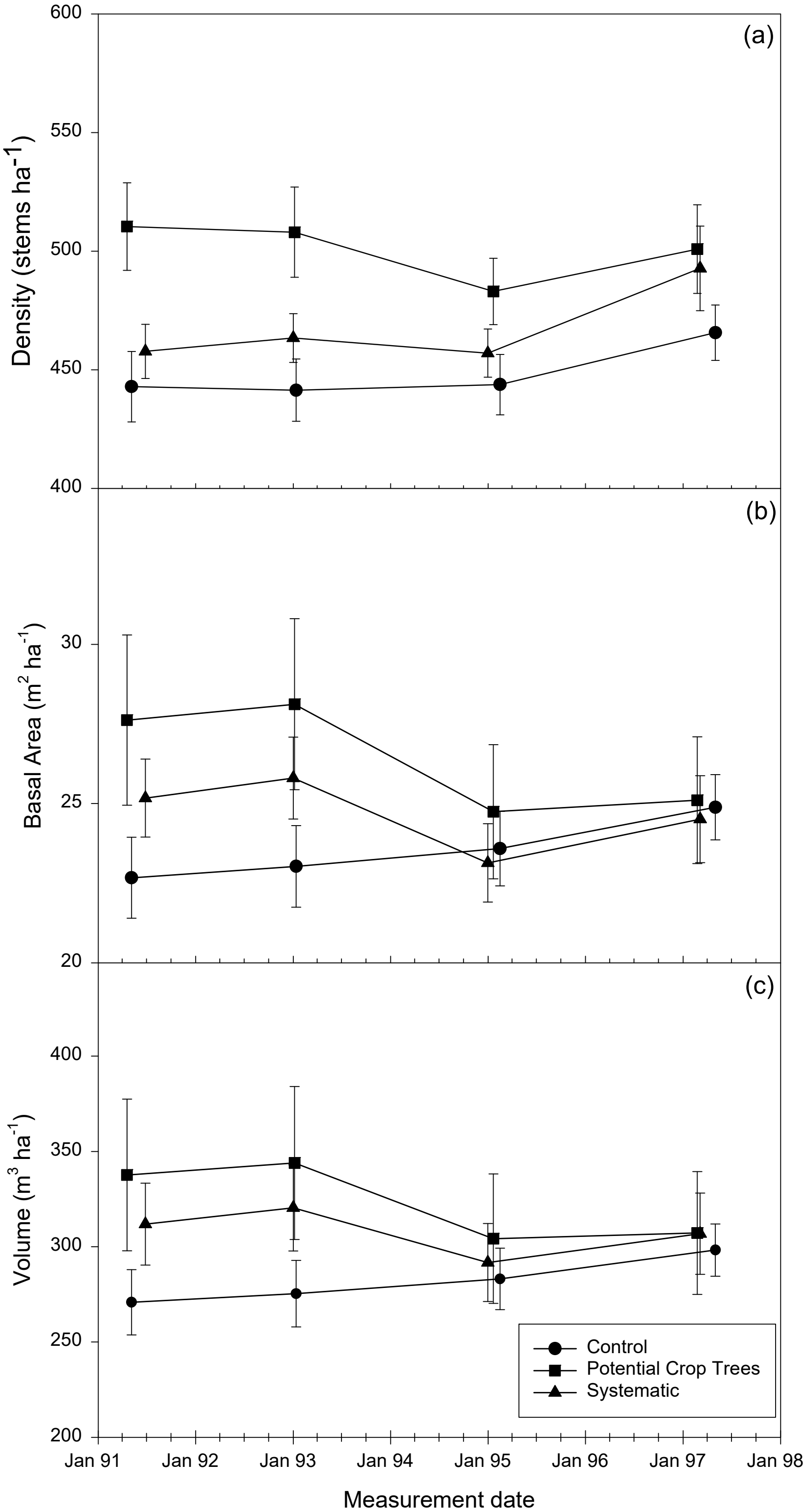

Figure 1. Stand structure for the thinning trial in RKL1. Data are the mean of eight one hectare plots ± 1 standard error.

3.3 STREK logging experiment

3.3.1 The STREK logging experiment had four treatments, a control, conventional logging, and reduced impact logging with diameter limits of 50 and 60 cm. The results from these treatments are summarised for the first four measurement campaigns in Fig. 2.

3.3.2 The mean commercial volume extracted from each treatment was reported by the STREK project to be 107.2 ± 34.4 $m^3 ha^{-1}$ for the conventional treatment with 96.8 ± 38.4 and 56.5 ± 16.5 m^3 ha^{-1} respectively for the reduced impact logging treatments with 50 and 60 cm diameter cutting limits (Sist & Bertault, 1998b). The observed reduction in total stand volume (Fig. 2) was 142, 134 and 106 m^3 ha^{-1} respectively for each of these treatments. The proportion of commercial volume extracted was thus highest in the conventional logging treatment (75 %) and lowest in the reduced impact logging treatment with a 60 cm diameter cutting limit (53 %). This result is counter-intuitive as reduced impact logging is meant to reduce the damage to the residual stand. The reasons for this observation need to be further investigated. One reason may be that the STREK analysis excluded data from plot 7 as this plot was subjected to excessive damage resulting from the construction of a secondary road (Sist & Bertault, 1998b).

3.3.3 The structure of the stand did not alter significantly between measurement campaigns two and three (Fig. 2). There were small, but insignificant reductions in the number of stems and total basal area of the plots. The recovery of the plots commenced between campaigns three and four, with a large increase in the number of stems, and relatively small increases in total basal area and volume of the plots (Fig. 2). Data from additional measurement campaigns are required to assess and compare the effective volume increment for the treatments.

3.3.4 The data presented in Fig. 2 represent the status of plots averaged over all size classes and species. This information is of academic interest, but is not adequate for management purposes. For this reason it is necessary to analyse the data based on size classes and species groups. An example of such an analysis is presented for the conventional logging treatment as Tables 1 to 6. The species grouping used in this analysis is based on an analysis of growth rates used for modelling purposes (Appendix I). The first five groups represent the majority of the commercial Dipterocarp species and these are used to define commercial volumes. Minor non-Dipterocarp species have been placed in the groups for small trees or others and unknowns.

Description of the logging treatment

3.3.5 Comparison of pre-logging data with results from campaign two, one year after logging can be used to describe the changes in basal area (Tables 1 & 2) or volume (Tables 4 & 5) resulting from logging. It is observed that only a proportion of the commercial Dipterocarp species were selected for logging, slow growing *Shorea* species such as *S. fallax* or *S. ovalis* and the genera of *Dipterocarpus, Parashorea* and *Dryobalanops*. The fast and medium growth rate species of *Shorea* were not extracted. These groups include species such as *S. johorensis, S. parvifolia* and *S. laevis* which would now be extracted by most commercial operations.

3.3.6 The logging operation used in the STREK trial left a significant volume of commercial species that could potentially be harvested at the second cutting cycle. Changes in market conditions since the trial was established means that it would be expected that current logging practice would be more severe. For this reason, the results of statistical analysis from the logging trial should not be extrapolated to current logging practice. The only appropriate approach will be to combine statistical analysis with suitable modelling techniques.

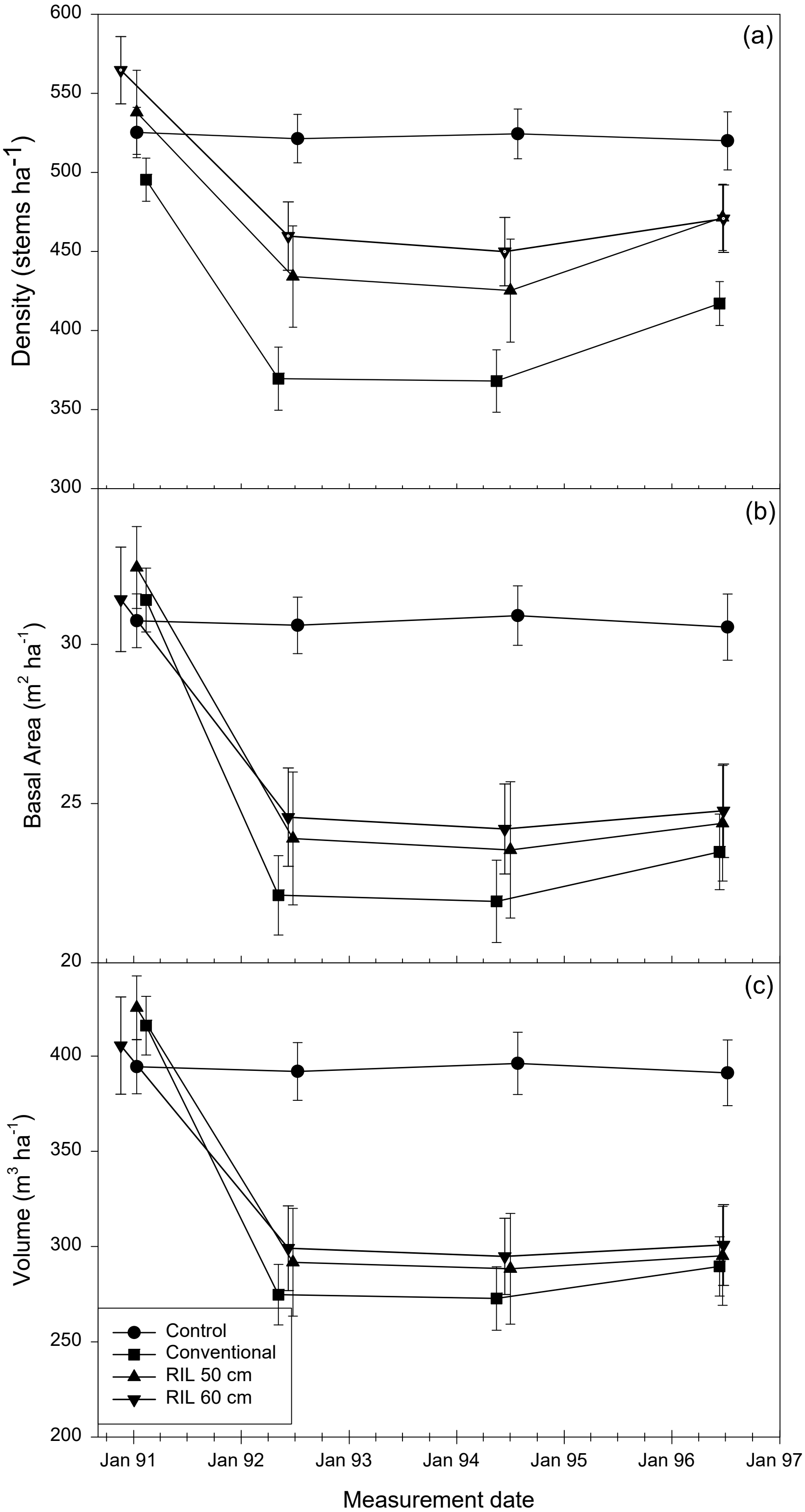

Figure 2. Stand structure for the logging trial in RKL4. Data are the mean of twelve one hectare plots ± 1 standard error.

Basal Area			Diameter Class				
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.3	0.3	0.5	0.3	0.7	1.6	3.7
Shorea, Medium growth	0.1	0.2	0.3	0.4	0.5	1.4	3.0
Shorea, Slow growth	0.3	0.3	0.4	0.7	1.1	2.3	5.2
Dryobalanops	0.3	0.4	0.4	0.8	0.8	3.9	6.5
Dipterocarpus	0.8	1.1	0.6	1.2	1.0	1.1	5.7
Macaranga	0.1	0.1	.	.	.	.	0.3
Anthocephalus	.	.	0.2	.	.	.	0.2
Small trees (Light)	0.1	0.1	0.2	.	.	.	0.4
Small trees (shade)	2.1	1.1	0.5	0.7	.	0.6	4.9
Others & unknown	5.1	3.8	1.0	1.1	0.6	1.0	12.6
Total	9.1	7.5	4.1	5.1	4.7	11.9	42.4

Table 1. Average basal area of plots before logging in the conventional logging treatment. Data were collected during the first measurement campaign between 30 February and 23 March 1991. Data are the mean of data from 12 one hectare plots, arranged as 4 adjacent squares in three locations.

Basal Area			Diameter Class				
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.3	0.3	0.5	0.3	0.9	1.5	3.8
Shorea, Medium growth	0.1	0.2	0.3	0.5	0.5	1.3	3.0
Shorea, Slow growth	0.1	0.2	0.3	.	0.6	1.4	2.7
Dryobalanops	0.1	0.3	0.4	0.3	0.5	1.3	2.9
Dipterocarpus	0.6	1.0	0.6	0.5	0.5	0.9	4.1
Macaranga	0.1	0.2	.	.	.	.	0.3
Anthocephalus	.	.	0.3	.	.	.	0.3
Small trees (Light)	0.1	0.1	0.2	.	.	.	0.4
Small trees (shade)	1.7	1.0	0.4	0.7	.	0.6	4.4
Others & unknown	3.8	3.3	0.9	1.0	0.6	0.9	10.4
Total	6.9	6.6	3.9	3.3	3.6	8.0	32.3

Table 2. Average basal area of plots one year after logging of the conventional logging treatment. Data were collected during the second measurement campaign between 30 April and 16 May 1992. Other details as for Table 1.

Basal Area			Diameter Class				
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.4	0.3	0.4	0.3	0.5	1.8	3.7
Shorea, Medium growth	0.1	0.3	0.2	0.7	0.4	1.5	3.2
Shorea, Slow growth	0.1	0.1	0.3	0.3	0.5	1.5	2.8
Dryobalanops	0.2	0.2	0.3	0.3	0.4	1.5	2.9
Dipterocarpus	0.7	0.9	0.8	0.6	0.5	1.1	4.5
Macaranga	0.3	0.3	.	.	.	0.9	1.6
Anthocephalus	0.2	0.1	.	0.3	.	.	0.6
Small trees (Light)	0.1	0.1	0.2	.	.	.	0.4
Small trees (shade)	1.8	1.0	0.4	0.7	0.4	0.6	5.0
Others & unknown	3.8	3.4	0.9	0.9	0.8	1.1	10.9
Total	7.7	6.7	3.6	4.1	3.5	9.9	35.5

Table 3. Average basal area of plots five years after logging of the conventional logging treatment. Data were collected during the fourth measurement campaign between 6 June and 15 June 1996. Other details as for Table 1.

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	2.6	4.4	6.4	4.7	11.1	24.5	53.7
Shorea, Medium growth	1.3	2.7	4.6	6.3	6.8	22.8	44.5
Shorea, Slow growth	2.3	3.7	6.1	10.3	17.0	38.2	77.7
Dryobalanops	2.5	4.6	5.3	11.2	12.1	63.1	98.8
Dipterocarpus	12.8	18.3	10.3	21.8	18.7	23.0	104.9
Macaranga	0.9	1.7	.	.	.	.	2.6
Anthocephalus	.	.	3.1	.	.	.	3.1
Small trees (Light)	0.6	0.9	2.8	.	.	.	4.3
Small trees (shade)	16.8	12.9	6.1	8.6	.	7.8	52.1
Others & unknown	42.7	44.5	12.7	14.0	8.6	13.4	135.8
Total	82.6	93.6	57.5	76.9	74.3	192.7	577.6

Table 4. Average total volume of plots before logging in the conventional logging treatment. Data were collected during the first measurement campaign between 30 February and 23 March 1991. Other details as for Table 1.

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	2.6	4.3	6.4	4.5	13.3	24.4	55.4
Shorea, Medium growth	1.3	2.7	4.7	7.7	6.9	21.1	44.5
Shorea, Slow growth	1.1	2.5	4.3	.	9.3	23.4	40.5
Dryobalanops	1.2	3.6	5.1	4.7	8.3	20.7	43.7
Dipterocarpus	9.4	16.9	10.3	9.8	9.8	19.1	75.3
Macaranga	0.9	1.8	.	.	.	.	2.7
Anthocephalus	.	.	3.2	.	.	.	3.2
Small trees (Light)	0.7	1.1	2.8	.	.	.	4.7
Small trees (shade)	13.9	11.5	5.7	8.6	.	7.8	47.5
Others & unknown	31.8	38.1	11.5	13.1	7.6	12.3	114.4
Total	63.0	82.5	53.9	48.4	55.2	128.9	431.9

Table 5. Average total volume of plots one year after logging of the conventional logging treatment. Data were collected during the second measurement campaign between 30 April and 16 May 1992. Other details as for Table 1.

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	3.1	4.4	6.0	4.7	6.8	27.8	52.9
Shorea, Medium growth	1.1	3.3	3.3	9.6	6.5	23.3	47.1
Shorea, Slow growth	0.8	1.7	4.6	4.3	7.5	24.5	43.3
Dryobalanops	1.4	2.8	4.0	4.6	6.8	24.4	44.1
Dipterocarpus	10.7	14.7	13.6	10.8	9.6	22.4	81.8
Macaranga	2.1	3.6	.	.	.	13.2	18.9
Anthocephalus	1.8	0.8	.	3.7	.	.	6.4
Small trees (Light)	0.9	1.1	3.0	.	.	.	5.0
Small trees (shade)	14.9	11.8	5.3	9.6	5.2	8.1	54.9
Others & unknown	32.1	39.2	11.6	11.7	10.8	14.8	120.1
Total	69.0	83.3	51.4	59.1	53.1	158.6	474.5

Table 6. Average total volume of plots five years after logging of the conventional logging treatment. Data were collected during the fourth measurement campaign between 6 June and 15 June 1996. Other details as for Table 1.

Rates of regrowth following logging.

3.3.7 Data from campaigns two and four can be compared to derive estimates of the rate of regrowth over the four years following logging. Comparison of total basal area shows an increase from 32.3 to 35.5 m^2 ha^{-1} (Tables 2 & 3) and an increase in total volume from 431.9 to 474.5 m^3 ha^{-1} (Tables 5& 6). This equates to a mean annual increment of 10.7 m^3 yr^{-1}. Further examination of the data shows that a large proportion of the total volume increment is for non-commercial species, especially *Macaranga* and *Anthocephalus*. The mean annual volume increment for the commercial Dipterocarp species is 2.5 m^3 yr^{-1}, with a proportion being well below the established diameter cutting limit of 50 cm.

3.3.8 It is doubtful that the initial rapid rates of regrowth will be maintained over the length of the cutting cycle. Growth rates would be expected to decline with time as canopy closure occurs. Data from campaign five will be useful as a comparison these results but may be confounded with reductions in growth rates resulting from the drought in 1997 and 1998 linked to the extreme *el nino* event in SE Asia. Further statistical and modelling analysis is required to examine these results.

3.3.9 The TPTI system in Indonesia is partly based upon an assumption that mean annual diameter increment for commercial species will be at least 1 cm yr^{-1}. Data from the logging trials have been analysed using results from campaigns three and four (Table 10). These were chosen because this was the first period of with significant increases in total stand basal area and volume (Fig. 2). The results show a significant increase in average diameter increments, with the increments of the commercial species in logged treatments up to two times greater than the controls. These rates did not, however, reach values of 1 cm yr^{-1}.

3.3.10 The fastest growth rates for individual trees were observed for the light demanding pioneer species of *Macaranga* and *Anthocephalus* species. These were the same groups as demonstrated the largest increases in total plot basal area and volume **(3.3.7)**.

Species Group	Control	Conventional	RIL 50	RIL 60
Shorea, Fast growth rate	0.37 ± 0.02	0.75 ± 0.04	0.64 ± 0.06	0.63 ± 0.03
Shorea, Medium growth rate	0.35 ± 0.03	0.72 ± 0.05	0.70 ± 0.06	0.62 ± 0.04
Shorea, Slow growth rate	0.32 ± 0.03	0.56 ± 0.06	0.62 ± 0.07	0.61 ± 0.05
Parashorea & *Dryobalanops*	0.37 ± 0.04	0.77 ± 0.07	0.58 ± 0.04	0.62 ± 0.05
Dipterocarpus & *Hopea*	0.23 ± 0.01	0.51 ± 0.02	0.41 ± 0.02	0.45 ± 0.01
Macaranga	0.35 ± 0.05	1.24 ± 0.16	1.54 ± 0.27	0.65 ± 0.08
Anthocephalus		2.70 ± 0.26	4.52 ± 0.57	2.22 ± 1.09
Small trees (Light Demanding)	0.38 ± 0.04	0.71 ± 0.13	0.71 ± 0.11	0.56 ± 0.05
Small trees (Shade tolerant)	0.14 ± 0.00	0.39 ± 0.01	0.34 ± 0.01	0.33 ± 0.01
Small trees (Other & unknown)	0.15 ± 0.00	0.42 ± 0.01	0.36 ± 0.01	0.34 ± 0.01

Table 10. Average mean annual diameter increment (MAI, cm yr-1) over the two year period between 1995 and 1997. RKL4, Logging trial. Data represent the mean of a variable number of individual trees ± 1 standard error.

3.4 Applying results to silviculture and forest management.

3.4.1 More detailed examination of the results from the thinning and logging trials suggests that the production of simple stand tables (e.g. Tables 1-9) or estimates of individual tree increment (Table 10) may be difficult to apply to forest management. The stand tables present a "snap-shot" view of the status of the stand at any one time, but cannot be directly extrapolated for management purposes. Stand tables are used to describe the state of the forest at any instant, and represent the net effect of a number of related processes.

3.4.2 When considering changes in basal area and volume, the relevant processes are growth, mortality and recruitment. For this purpose, recruitment is defined as individuals growing above the minimal measurement size, which for the STREK plots as a DBH of 10 cm. When data are presented split into size classes, the analysis needs in addition to consider ingrowth and outgrowth, which are defined as individuals crossing the minimum or maximum size limits for each class. Experimental treatments such as logging or thinning can also be described as processes that alter the basal area and total volume of a plot. It is the balance of these processes that determine the state of a plot at any time. Results also need to be presented to describe the effective commercial volume of plots. This is the total volume of commercial species that exceeds the diameter limit for logging.

3.4.3 The STREK experiments consisted of a number of silvicultural treatments. The statistical analysis of these experiments, must quantify the magnitudes of the processes of growth, recruitment and mortality, as well as losses directly resulting from the silvicultural treatments. These statistics can then be used to compare the experimental treatments. Results from this type of analysis can also be used to derive a simple mathematical model to describe net changes in stand structure with time. More complex modelling will be required to make projections on the likely status of each type of plot at the end of a set cutting cycle. An example will be given in the next section of this report.

4 Assessing opportunities for application of PSP and Inventory data to forest management by Inhutani I at Labanan.

4.1 Introduction

4.1.1 The previous section considered the statistical analysis of PSP data from the STREK plots and concluded that such analysis should not be used alone to support forest management. The development of a yield scheduling system for the Inhutani concession will require the development of a system that integrates PSP and inventory data with the GIS environmental framework. In this system, yield scheduling should be based upon a combination of statistical and modelling approaches using inventory and PSP data.

4.1.2 The BFMP project has considered the application of three modelling tools for yield scheduling. These are the BFMP Yield Simulation System (YSS), DIPSIM developed by GTZ and SYMFOR developed by the UK Department for International Development.

4.2 BFMP, Integrated Yield Simulation System.

4.2.1 The yield simulation system, (YSS) (Rombouts, 1998) was designed to be linked with the GIS environmental framework for the Labanan concession. It is based upon a simple transition matrix growth model derived from work in Queensland (Vanclay, 1989). The BFMP system has been developed to use inventory data that has been stratified using the environmental framework. It was calibrated using PSP data from the STREK and ITCI projects in East Kalimantan obtained from the Growth and Yield Data System (GYDS) of BPK- Samarinda.

4.2.2 The initial application of the system showed that the application of the TPTI system to the concession could support annual production levels of up to 67,000-73,000 m^3 over a cutting cycle of 35 years. This requires the assumption that no areas are lost from production through fires, illegal logging or conversion. This equated to an average increment in net commercial volume of between 0.71 and 0.65 $m^3\ yr^{-1}$.

4.2.3 The growth models were derived using data from the STREK and ITCI projects. New data from the STREK plots will be available in the second quarter of 1999. These should be used to update the calibration of the models used by the YSS. Significant changes have been made to the BFMP inventory and environmental framework since the initial evaluation of the yield simulation system. The yield simulation system should be re-run when revised data from the STREK plots and BFMP inventory are available for model calibration and initialisation.

4.3 DIPSIM.

4.3.1 The latest version of DIPSIM has been developed by GTZ specifically for use in Kalimantan. The model was demonstrated during a workshop on growth and yield prediction organised by Ditjen PH in Bogor during March 1999. DIPSIM was promoted as a tool to support decisions on appropriate levels of annual allowable cut (AAC) for a concession.

4.3.2 The current implementation of DIPSIM is linked directly to the systematic inventory design used by the GTZ Sustainable Forest Management Project (SFMP) in East Kalimantan. For this reason, DIPSIM cannot be directly applied for the Labanan concession using existing inventory data. It may be possible to generate data in an appropriate format for use with DIPSIM using the BFMP environmental framework. This process would greatly simplified if DIPSIM could be modified to work with variable sized compartments. These options should be discussed with GTZ staff.

4.4 SYMFOR

4.4.1 SYMFOR has been developed by the UK Department for International Development (DFID) as a tool supporting sustainable forest management and in particular the evaluation of silvicultural systems. SYMFOR requires data from one hectare plots including tree position to initialise each run. This requirement makes the model incompatible with the current BFMP inventory used at the Labanan concession. There have been discussions between BFMP staff and the developers of the programme to resolve this issue. Two options have been suggested, the first would establish additional permanent sample plots for the Labanan concession. The second would require the generation of artificial plot data from existing forest inventory.

4.4.2 A new version of SYMFOR (SYMFOR^{99}) was released at the PH sponsored workshop on growth and yield regulation. This model has been run using data from the STREK logging trial to illustrate the application of this model for yield scheduling and a comparison of silvicultural treatments.

4.4.3 Two sets of simulations were run using data from the STREK logging trial describing the treatments of conventional logging and reduced impact logging with a 60 cm diameter limit. Each simulation used all twelve one hectare plots for the treatment with ten replicate simulations per plot. This approach is required to generate a statistical description of the results as the model is stochastic, that is it includes random components and as such no two runs will produce identical results.

4.4.4 Data from the conventional logging treatment are presented as Tables 11 – 16. Data measured in the plots, two years after logging are presented for basal area, volume and stem numbers as Tables 11 – 13. Data are presented as the mean and standard error for the twelve plots. This permits comparison of variability between treatments and with the modelled results. The same data were used as input for the SYMFOR model, which was run to simulate 33 years of growth, taking the plots up to the end of the first cutting cycle as specified by the TPTI system. The results are presented as Tables 14 – 16 for basal area, volume and stem numbers.

4.4.5 The total basal area of the plots is predicted to increase from 22.12 ± 1.25 m^2 ha^{-1} to 30.44 ± 0.25 m^2 ha^{-1} over the 33 years of simulations (Tables 11 & 14). This final value is significantly lower than the value of 42 m^2 ha^{-1} measured before logging in the same plots (Table 1). A similar result is observed for total stand volume, which is predicted to increase from 265.6 ± 15.3 m^3 ha^{-1} to 363.1 m^3 ha^{-1} over the period of simulation. The final value is again very significantly lower than the value of 577.7 m^3 ha^{-1} measured before logging (Table 2).

4.4.6 The modelled data can be examined to consider if there will be sufficient commercial volume to support a second cut after 35 years of growth. The sum the volume of trees of all commercial species with diameters greater than 50 cm is 102.1 m^3 ha^{-1} (Table 23). This should be adequate to support a harvest. It was previously noted that the logging treatments in the STREK trial had left a large commercial volume in the stand. For the conventional logging treatment this was 88.5 m^3 ha^{-1} hence it must be concluded that the second harvest will be mainly extracting volume that was left by the first harvest. The volume increment predicted for the plots of 13.6 m^3 over the cutting cycle or 0.41 m^3 yr^{-1} would not support a viable commercial harvest over the same length of cutting cycle. This suggests that the assessment of a sustainable cut for the concession should be defined in terms of acceptable changes in stand volume (stocking) and net commercial volume increment.

Basal Area (m^2 ha^{-1})	Diameter Class 10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.27±0.09	0.34±0.06	0.27±0.08	0.08±0.04	0.15±0.11	0.65±0.26	1.75±0.30
Shorea, Medium growth	0.15±0.03	0.18±0.05	0.08±0.05	0.18±0.09	0.11±0.06	0.88±0.30	1.57±0.42
Shorea, Slow growth	0.08±0.03	0.13±0.05	0.18±0.05	0.00±0.00	0.15±0.09	0.48±0.23	1.02±0.25
Dryobalanops	0.14±0.02	0.28±0.04	0.12±0.06	0.03±0.03	0.18±0.08	0.86±0.28	1.61±0.33
Dipterocarpus	0.58±0.09	1.03±0.24	0.58±0.11	0.22±0.09	0.17±0.08	0.39±0.17	2.96±0.48
Macaranga	0.10±0.03	0.05±0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.15±0.04
Anthocephalus	0.00±0.00	0.00±0.00	0.02±0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.02±0.02
Small trees (Light)	0.06±0.02	0.01±0.01	0.04±0.03	0.00±0.00	0.00±0.00	0.00±0.00	0.10±0.03
Small trees (shade)	1.71±0.17	0.99±0.21	0.22±0.10	0.22±0.10	0.00±0.00	0.10±0.06	3.23±0.52
Others & unknown	3.76±0.20	3.27±0.32	0.90±0.18	0.83±0.16	0.43±0.09	0.52±0.17	9.71±0.58
Total	6.83±0.38	6.28±0.52	2.41±0.34	1.55±0.31	1.19±0.20	3.87±0.48	22.12±1.25

Table 11. Mean basal area of plots. Conventional logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Data are the mean of twelve one hectare plots ± 1 standard error.

Volume (m^3 ha^{-1})	Diameter Class 10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	2.9±0.9	4.8±0.8	4.0±1.2	1.2±0.6	2.4±1.8	10.8±4.3	26.1±5.1
Shorea, Medium growth	1.3±0.3	2.1±0.6	1.1±0.7	2.5±1.3	1.7±0.9	14.1±4.9	22.9±6.6
Shorea, Slow growth	0.7±0.3	1.6±0.6	2.5±0.7	0.0±0.0	2.3±1.3	7.7±3.7	14.8±3.8
Dryobalanops	1.2±0.2	3.6±0.5	1.7±0.8	0.4±0.4	2.8±1.3	13.8±4.5	23.5±5.1
Dipterocarpus	5.4±0.9	13.0±3.0	7.9±1.5	3.1±1.3	2.5±1.2	6.0±2.6	37.9±6.3
Macaranga	0.8±0.2	0.6±0.3	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	1.4±0.4
Anthocephalus	0.0±0.0	0.0±0.0	0.3±0.3	0.0±0.0	0.0±0.0	0.0±0.0	0.3±0.3
Small trees (Light)	0.5±0.2	0.1±0.1	0.5±0.3	0.0±0.0	0.0±0.0	0.0±0.0	1.1±0.4
Small trees (shade)	13.9±1.5	11.5±2.5	2.8±1.3	2.9±1.3	0.0±0.0	1.3±0.9	32.5±5.9
Others & unknown	31.8±1.8	38.1±3.8	11.5±2.3	10.9±2.1	5.7±1.3	7.2±2.4	105.2±6.8
Total	58.7±3.5	75.5±6.2	32.3±4.5	21.0±4.2	17.3±3.1	60.8±7.6	265.6±15.3

Table 12. Mean volume of plots. Reduced impact logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Other details as for Table 11.

Stem number (ha^{-1})	Diameter Class 10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	11.0±3.4	2.7±0.4	1.2±0.3	0.3±0.1	0.3±0.3	0.8±0.3	16.3±3.2
Shorea, Medium growth	4.6±0.7	1.5±0.4	0.3±0.2	0.5±0.3	0.3±0.1	0.9±0.3	8.1±0.9
Shorea, Slow growth	2.5±1.0	1.3±0.4	0.8±0.2	0.0±0.0	0.3±0.2	0.6±0.3	5.4±1.5
Dryobalanops	5.4±0.7	2.3±0.3	0.5±0.2	0.1±0.1	0.4±0.2	1.0±0.3	9.8±1.1
Dipterocarpus	23.7±3.4	8.3±1.8	2.5±0.5	0.7±0.3	0.4±0.2	0.6±0.3	36.2±5.2
Macaranga	4.2±1.1	0.4±0.2	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	4.6±1.1
Anthocephalus	0.0±0.0	0.0±0.0	0.1±0.1	0.0±0.0	0.0±0.0	0.0±0.0	0.1±0.1
Small trees (Light)	2.2±0.6	0.1±0.1	0.2±0.1	0.0±0.0	0.0±0.0	0.0±0.0	2.4±0.7
Small trees (shade)	80.4±6.9	8.8±1.7	0.9±0.4	0.7±0.3	0.0±0.0	0.2±0.1	90.9±8.9
Others & unknown	158.5±7.8	29.2±2.7	3.9±0.8	2.5±0.5	1.0±0.2	0.8±0.2	195.8±9.6
Total	292.4±15.5	54.5±4.3	10.3±1.4	4.7±0.9	2.8±0.5	4.8±0.6	369.5±19.9

Table 13. Mean number of stems in plots. Reduced impact logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Other details as for Table 11.

Basal Area	Diameter Class						
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.49±0.01	1.00±0.05	0.47±0.03	0.31±0.03	0.30±0.03	0.65±0.08	3.23±0.12
Shorea, Medium growth	0.11±0.01	0.24±0.02	0.17±0.02	0.11±0.02	0.10±0.02	0.88±0.11	1.61±0.12
Shorea, Slow growth	0.07±0.00	0.14±0.02	0.08±0.01	0.09±0.02	0.11±0.02	0.44±0.06	0.93±0.08
Dryobalanops	0.24±0.01	0.25±0.02	0.10±0.01	0.10±0.02	0.06±0.02	0.50±0.07	1.26±0.09
Dipterocarpus	0.61±0.02	1.16±0.06	0.64±0.05	0.67±0.06	0.41±0.04	0.47±0.07	3.95±0.18
Macaranga	0.17±0.01	0.53±0.03	0.30±0.03	0.00±0.00	0.00±0.00	0.00±0.00	1.00±0.05
Anthocephalus	0.03±0.00	0.18±0.03	0.14±0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.35±0.05
Small trees (Light)	0.11±0.01	0.19±0.02	0.03±0.01	0.01±0.00	0.01±0.01	0.00±0.00	0.35±0.02
Small trees (shade)	2.81±0.05	1.89±0.07	0.42±0.04	0.19±0.03	0.15±0.03	0.10±0.03	5.54±0.16
Others & unknown	4.71±0.04	4.81±0.10	1.16±0.06	0.63±0.04	0.45±0.04	0.44±0.06	12.20±0.16
Total	9.34±0.06	10.39±0.11	3.52±0.08	2.12±0.10	1.58±0.07	3.49±0.18	30.44±0.25

Table 14. Modelled basal area of plots. Data summarise the projected status of the stand 35 years after logging using conventional logging techniques. Data are the mean of ten replicate simulations using SYMFOR[99] for each of twelve replicate one hectare plots. Data are reported as the mean ± 1 standard error

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	5.5±0.2	13.8±0.7	7.1±0.5	4.9±0.5	4.8±0.5	10.9±1.4	47.0±1.9
Shorea, Medium growth	1.0±0.1	3.0±0.2	2.3±0.2	1.6±0.3	1.4±0.3	14.2±1.8	23.6±1.9
Shorea, Slow growth	0.6±0.0	1.8±0.2	1.2±0.2	1.3±0.2	1.7±0.3	7.1±1.1	13.6±1.2
Dryobalanops	2.1±0.1	3.2±0.2	1.5±0.2	1.5±0.3	0.9±0.3	8.1±1.2	17.4±1.4
Dipterocarpus	5.9±0.2	14.5±0.7	8.8±0.7	9.5±0.9	6.0±0.6	7.3±1.0	52.1±2.4
Macaranga	1.5±0.1	6.3±0.3	3.8±0.4	0.1±0.0	0.0±0.0	0.0±0.0	11.6±0.7
Anthocephalus	0.2±0.0	2.2±0.3	1.7±0.3	0.0±0.0	0.0±0.0	0.0±0.0	4.2±0.5
Small trees (Light)	1.0±0.1	2.2±0.2	0.4±0.1	0.1±0.1	0.1±0.1	0.0±0.0	3.9±0.3
Small trees (shade)	24.0±0.4	21.8±0.8	5.3±0.5	2.4±0.3	1.9±0.4	1.4±0.4	57.0±1.9
Others & unknown	41.5±0.4	56.0±1.1	14.7±0.7	8.3±0.6	6.1±0.6	6.1±0.8	132.7±1.9
Total	83.5±0.6	124.9±1.4	46.8±1.1	29.8±1.5	23.0±1.1	55.2±2.9	363.1±3.6

Table 15. Modelled volume of plots. Data summarise the projected status of the stand 35 years after logging using conventional logging techniques. Other details as for Table 14.

Stem number	Diameter Class						
(ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	16.6±0.4	8.4±0.4	2.0±0.1	1.0±0.1	0.7±0.1	0.8±0.1	29.5±0.7
Shorea, Medium growth	3.9±0.2	1.9±0.1	0.7±0.1	0.3±0.1	0.2±0.0	0.9±0.1	8.0±0.3
Shorea, Slow growth	2.5±0.1	1.1±0.1	0.4±0.1	0.3±0.0	0.3±0.0	0.5±0.1	5.0±0.3
Dryobalanops	8.4±0.3	2.2±0.2	0.4±0.0	0.3±0.1	0.1±0.0	0.5±0.1	12.1±0.4
Dipterocarpus	20.3±0.5	9.7±0.5	2.7±0.2	2.0±0.2	1.0±0.1	0.7±0.1	36.4±1.0
Macaranga	6.2±0.3	4.2±0.2	1.3±0.1	0.0±0.0	0.0±0.0	0.0±0.0	11.6±0.5
Anthocephalus	0.8±0.1	1.3±0.2	0.6±0.1	0.0±0.0	0.0±0.0	0.0±0.0	2.7±0.3
Small trees (Light)	3.3±0.2	1.7±0.2	0.2±0.0	0.0±0.0	0.0±0.0	0.0±0.0	5.2±0.3
Small trees (shade)	115.1±1.5	17.7±0.6	1.8±0.2	0.6±0.1	0.3±0.1	0.1±0.0	135.6±1.9
Others & unknown	174.8±1.1	43.0±0.8	5.0±0.2	2.0±0.1	1.0±0.1	0.6±0.1	226.4±1.6
Total	352.1±1.8	91.2±1.0	15.2±0.3	6.5±0.3	3.6±0.2	4.1±0.2	472.5±1.7

Table 16. Modelled number of stems in plots. Data summarise the projected status of the stand 35 years after logging using conventional logging techniques. Other details as for Table 14.

Basal Area	Diameter Class						
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.37±0.05	0.39±0.05	0.16±0.06	0.30±0.10	0.07±0.07	0.97±0.29	2.26±0.46
Shorea, Medium growth	0.10±0.03	0.23±0.06	0.14±0.07	0.17±0.07	0.12±0.08	0.20±0.11	0.96±0.19
Shorea, Slow growth	0.10±0.02	0.14±0.05	0.15±0.05	0.00±0.00	0.00±0.00	0.40±0.16	0.78±0.16
Dryobalanops	0.11±0.02	0.18±0.06	0.13±0.05	0.11±0.05	0.11±0.08	0.10±0.07	0.74±0.25
Dipterocarpus	0.73±0.12	1.51±0.27	1.04±0.23	0.48±0.12	0.28±0.09	0.59±0.24	4.63±0.87
Macaranga	0.09±0.02	0.09±0.03	0.02±0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.19±0.05
Anthocephalus	0.00±0.00	0.01±0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.01±0.01
Small trees (Light)	0.10±0.03	0.16±0.06	0.10±0.05	0.02±0.02	0.04±0.04	0.00±0.00	0.42±0.08
Small trees (shade)	2.42±0.13	1.27±0.13	0.21±0.05	0.22±0.07	0.18±0.12	0.33±0.12	4.63±0.35
Others & unknown	4.60±0.24	3.05±0.24	0.84±0.18	0.56±0.10	0.32±0.08	0.58±0.26	9.96±0.54
Total	8.61±0.40	7.03±0.52	2.77±0.39	1.87±0.19	1.11±0.18	3.17±0.50	24.57±1.54

Table 17. Mean basal area of plots. Reduced impact logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Data are the mean of twelve one hectare plots ± 1 standard error.

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	4.0±0.6	5.4±0.7	2.4±0.9	4.7±1.6	1.1±1.1	16.2±4.8	33.8±7.3
Shorea, Medium growth	0.9±0.2	2.9±0.7	1.8±0.9	2.4±1.0	1.7±1.2	3.2±1.8	13.0±2.8
Shorea, Slow growth	0.9±0.2	1.7±0.6	2.1±0.7	0.0±0.0	0.0±0.0	6.3±2.5	11.0±2.5
Dryobalanops	0.9±0.2	2.3±0.7	1.8±0.7	1.6±0.7	1.7±1.2	1.5±1.0	9.8±3.5
Dipterocarpus	7.0±1.2	19.1±3.5	14.3±3.2	6.9±1.7	4.1±1.4	9.0±3.6	60.3±11.8
Macaranga	0.8±0.2	1.0±0.4	0.2±0.2	0.0±0.0	0.0±0.0	0.0±0.0	2.0±0.6
Anthocephalus	0.0±0.0	0.1±0.1	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.1±0.1
Small trees (Light)	0.8±0.3	1.9±0.7	1.3±0.6	0.3±0.3	0.5±0.5	0.0±0.0	4.8±0.9
Small trees (shade)	19.9±1.2	14.7±1.5	2.6±0.7	2.9±1.0	2.5±1.6	4.5±1.7	47.1±4.3
Others & unknown	38.6±2.0	35.6±2.9	10.6±2.3	7.4±1.2	4.3±1.1	8.0±3.5	104.4±6.4
Total	73.7±3.5	84.8±6.3	37.1±5.2	26.1±2.7	15.8±2.7	48.8±7.6	286.3±20.4

Table 18. Mean volume of plots. Reduced impact logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Other details as for Table 17.

Stem number	Diameter Class						
(ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	15.2±2.7	3.3±0.5	0.7±0.3	0.9±0.3	0.2±0.2	1.3±0.4	21.5±2.9
Shorea, Medium growth	3.8±0.7	1.8±0.4	0.6±0.3	0.5±0.2	0.3±0.2	0.3±0.1	7.2±1.1
Shorea, Slow growth	3.3±0.8	1.1±0.4	0.7±0.2	0.0±0.0	0.0±0.0	0.5±0.2	5.5±1.0
Dryobalanops	5.3±1.1	1.6±0.5	0.5±0.2	0.3±0.1	0.3±0.2	0.2±0.1	8.2±1.7
Dipterocarpus	28.2±4.1	12.3±2.2	4.5±1.0	1.5±0.4	0.7±0.2	0.8±0.3	47.9±7.3
Macaranga	3.2±0.6	0.8±0.3	0.1±0.1	0.0±0.0	0.0±0.0	0.0±0.0	4.0±0.9
Anthocephalus	0.0±0.0	0.1±0.1	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.1±0.1
Small trees (Light)	4.2±0.8	1.5±0.7	0.4±0.2	0.1±0.1	0.1±0.1	0.0±0.0	6.3±1.1
Small trees (shade)	111.8±5.1	11.6±1.0	1.0±0.2	0.7±0.2	0.4±0.3	0.5±0.2	125.9±5.5
Others & unknown	198.8±10.8	27.3±1.9	3.7±0.8	1.8±0.3	0.8±0.2	0.9±0.4	233.2±11.6
Total	373.7±18.1	61.1±4.3	12.1±1.7	5.8±0.6	2.6±0.4	4.5±0.8	459.7±21.6

Table 19. Mean number of stems in plots. Reduced impact logging treatment with 60 cm diameter cutting limit. Data measured two years after logging. Other details as for Table 17.

Basal Area	Diameter Class						
(m^2 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	0.39±0.01	0.97±0.04	0.50±0.03	0.33±0.03	0.30±0.03	0.90±0.09	3.38±0.13
Shorea, Medium growth	0.08±0.01	0.23±0.02	0.09±0.01	0.14±0.02	0.13±0.02	0.40±0.05	1.07±0.06
Shorea, Slow growth	0.07±0.00	0.15±0.01	0.06±0.01	0.11±0.02	0.08±0.02	0.32±0.05	0.80±0.06
Dryobalanops	0.17±0.01	0.22±0.02	0.05±0.01	0.06±0.01	0.04±0.01	0.09±0.02	0.63±0.04
Dipterocarpus	0.64±0.02	1.40±0.07	0.92±0.05	1.02±0.08	0.67±0.06	0.83±0.08	5.48±0.26
Macaranga	0.10±0.01	0.34±0.02	0.16±0.02	0.00±0.00	0.00±0.00	0.00±0.00	0.61±0.03
Anthocephalus	0.02±0.00	0.06±0.01	0.03±0.01	0.00±0.00	0.00±0.00	0.00±0.00	0.11±0.01
Small trees (Light)	0.09±0.01	0.29±0.02	0.11±0.02	0.09±0.02	0.05±0.01	0.02±0.01	0.66±0.04
Small trees (shade)	3.39±0.04	2.51±0.06	0.50±0.03	0.15±0.02	0.11±0.02	0.50±0.06	7.15±0.14
Others & unknown	5.17±0.06	5.08±0.08	1.07±0.05	0.51±0.04	0.32±0.03	0.52±0.07	12.66±0.15
Total	10.11±0.09	11.25±0.11	3.49±0.10	2.41±0.09	1.70±0.07	3.59±0.18	32.55±0.32

Table 20. Modelled basal area of plots. Data summarise the projected status of the stand 35 years after logging using reduced impact logging with a 60 cm diameter cutting limit. Data are the mean of ten replicate simulations using SYMFOR[99] for each of twelve replicate one hectare plots. Data are reported as the mean ± 1 standard error.

Volume	Diameter Class						
(m^3 ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	4.3±0.1	13.4±0.6	7.5±0.5	5.1±0.5	4.7±0.5	15.2±1.6	50.3±2.1
Shorea, Medium growth	0.7±0.1	2.8±0.2	1.2±0.2	2.0±0.3	1.9±0.3	6.3±0.8	15.0±1.0
Shorea, Slow growth	0.6±0.0	1.9±0.2	0.9±0.2	1.7±0.3	1.2±0.2	5.2±0.8	11.4±1.0
Dryobalanops	1.5±0.1	2.8±0.2	0.8±0.1	0.8±0.2	0.6±0.2	1.4±0.3	7.9±0.6
Dipterocarpus	6.4±0.2	17.6±0.9	12.7±0.7	14.6±1.1	9.8±0.9	12.8±1.3	73.8±3.7
Macaranga	0.9±0.1	4.1±0.3	2.0±0.3	0.0±0.0	0.0±0.0	0.0±0.0	7.0±0.4
Anthocephalus	0.1±0.0	0.8±0.1	0.4±0.1	0.0±0.0	0.0±0.0	0.0±0.0	1.3±0.2
Small trees (Light)	0.8±0.1	3.4±0.2	1.5±0.3	1.2±0.2	0.7±0.2	0.3±0.1	7.9±0.5
Small trees (shade)	29.6±0.4	29.1±0.7	6.3±0.4	1.9±0.2	1.5±0.3	7.0±0.9	75.3±1.7
Others & unknown	46.5±0.6	59.0±0.9	13.6±0.6	6.6±0.5	4.3±0.4	7.1±0.9	137.1±1.8
Total	91.4±0.9	134.7±1.3	46.8±1.4	34.0±1.3	24.8±1.1	55.3±2.8	387.1±4.7

Table 21. Modelled volume of plots. Data summarise the projected status of the stand 35 years after logging using reduced impact logging with a 60 cm diameter cutting limit. Other details as for Table 20.

Stem number	Diameter Class						
(ha^{-1})	10-29.9	30-49.9	50-59.9	60-69.9	70-79.9	80+	Total
Shorea, Fast growth	13.4±0.4	8.0±0.3	2.1±0.2	1.0±0.1	0.7±0.1	1.0±0.1	26.2±0.5
Shorea, Medium growth	2.9±0.2	1.9±0.1	0.4±0.1	0.4±0.1	0.3±0.0	0.6±0.1	6.5±0.3
Shorea, Slow growth	2.2±0.1	1.3±0.1	0.3±0.0	0.3±0.1	0.2±0.0	0.3±0.0	4.6±0.2
Dryobalanops	5.9±0.3	2.0±0.1	0.2±0.0	0.2±0.0	0.1±0.0	0.1±0.0	8.5±0.3
Dipterocarpus	20.1±0.5	11.8±0.6	3.9±0.2	3.1±0.2	1.6±0.1	1.1±0.1	41.5±1.2
Macaranga	4.1±0.2	2.7±0.2	0.7±0.1	0.0±0.0	0.0±0.0	0.0±0.0	7.4±0.3
Anthocephalus	0.6±0.1	0.5±0.1	0.1±0.0	0.0±0.0	0.0±0.0	0.0±0.0	1.2±0.1
Small trees (Light)	2.7±0.1	2.5±0.2	0.5±0.1	0.3±0.0	0.1±0.0	0.0±0.0	6.1±0.3
Small trees (shade)	130.7±1.3	23.4±0.6	2.2±0.1	0.5±0.1	0.3±0.0	0.6±0.1	157.6±1.6
Others & unknown	177.1±1.5	46.5±0.7	4.7±0.2	1.6±0.1	0.7±0.1	0.8±0.1	231.3±1.8
Total	359.6±2.3	100.5±1.0	15.0±0.4	7.4±0.3	4.0±0.2	4.6±0.2	490.9±2.5

Table 22. Modelled number of stems in plots. Data summarise the projected status of the stand 35 years after logging using reduced impact logging with a 60 cm diameter cutting limit. Other details as for Table 20.

	Conventional logging		Reduced impact logging	
	Total volume	Commercial	Total volume	Commercial
Two years post logging	265.6	88.5	286.3	85.1
35 years post logging	363.1	102.1	387.1	106.4
Total increment (m^3)	97.5	13.6	100.8	21.3
Annual increment (m^3 yr^{-1})	2.95	0.41	3.05	0.65

Table 23. Summary of measured and modelled volume data from Tables 2, 5, 8 and 11. Data for two years post logging were measured, whilst the 35 years post logging data represent modelled predictions. Commercial volume was calculated as the sum of Dipterocarp species groups with diameters exceeding 50 cm. Annual volume increment was calculated for the 33 year interval between the measured and modelled data.

4.4.7 Simulations using the reduced impact logging plots produced similar results (Tables 17 – 22). There was a significant increase in the total basal area from 24.57 ± 1.54 m^2 ha^{-1} up to 32.55 ± 0.32 m^2 ha^{-1} at the end of the simulation. This value is significantly lower than that observed in unlogged forest, though data for these plots is not presented in this report. The increase in total volume in the plots was 100.8 m^3 (Table 23). The commercial volume increment of 21.3 m^3 or 0.65 m^3 yr^{-1} was 50 % higher than that predicted for the conventional logging treatment, but again would be considered insufficient to support sustainable harvesting with a 35 year cutting cycle.

4.4.8 The results from the current version of SYMFOR gives estimates of growth that are similar o those obtained by the BFMP yield simulation system. Comparison of modelled predictions with measurements of diameter increment have shown that there is a large residual variability in the observed dataset. Similar variation in the inventory has at least partly been explained using the BFMP environmental framework to generate indices of topography or slope position. It would seem logical to attempt to extend the SYMFOR modelling approach to include one or more indices describing the local environment.

4.4.9 The modelling analysis presented suggests the following conclusions:

- Reduced impact logging is likely to result in enhanced volume increments in the residual stand.
- A 35 year cutting cycle is insufficient to support commercial logging activities using current definitions of commercial species and cutting limits.
- A second cut may be possible in many areas of the concession after 35 years utilising commercial volume that was left during the first harvest. This approach could not be repeated for subsequent cutting cycles.
- The modelling analysis should be extended to include a description of topography or slope position.

4.5 An integrated yield scheduling system for the Labanan concession.

4.5.1 The BFMP integrated yield simulation system (Rombouts, 1998) was produced as a first prototype for a system to forecast and schedule yield for the Labanan concession. This work developed the basic framework for an operational system. The GIS-based environmental framework for the concession should be used to stratify inventory and sample plot data for subsequent statistical analysis and modelling activities. Results from models including the YSS, DIPSIM and SYMFOR can then be used to produce projections of the likely status of the forest at intervals in the future. This information can then be used to evaluate the sustainability of various silvicultural and harvesting options.

4.5.2 The documentation for the BFMP yield simulation system (Rombouts, 1998) developed a framework for the linking components to develop a yield scheduling system for the Labanan concession (Fig. 3). This work identifies a number of key steps. These are:

Integration of GIS and KPHP inventory.

4.5.3 The GIS coverages are used to create a system to stratify inventory plots and calculate the area of each stratum. This work is currently being implemented by BFMP and Inhutani staff who are processing and updating the inventory for the concession.

Integration of GIS and PSP programme.

4.5.4 The GIS should be used to derive indices of site quality. These can be used to categorise existing permanent sample plots and to suggest locations for the creation of new plots. These should be located to characterise a wider range of sites. Similar approaches can be used to relate modelled growth to soil and topography.

Integration of KPHP inventory and PSP programme and growth model components.

4.5.5 There is an urgent need to link the existing data from the KPHP inventory and PSP programmes. Part of this work has been completed by the correcting the location of the STREK plots within the BFMP GIS. This has allowed an assessment of the characteristics of the plots in relation to the environmental and forest strata for the concession.

Creating a Yield Simulation System

4.5.6 The yield simulation system consists of a number of statistical and modelling components that can be used to work with inventory and PSP data and project their status in the future. The growth components of the system could use any of the models discussed in this report. Harvesting modules are required to establish the commercial yield according to rules for logging set by regulation and commercial considerations. All of the models suggested for growth modelling also contain harvesting modules using rules derived from the TPTI regulations. The BFMP YSS also models the impact of forest conversion on long-term sustainability.

4.5.7 The results from yield simulation need to be presented to end-users in a form that will support forest management. The BFMP YSS and DIPSIM directly produce output in such a format. SYMFOR uses an alternative approach that outputs data for each plot in the same format as used for data input. This means that the results can be integrated directly with existing PSP or inventory databases as part of a concession management information system using established analysis and reporting tools.

Yield scheduling

4.5.8 The objective of creating an integrated system for yield simulation is to develop robust methods to promote the sustainable management of forest resources. A yield simulation system is, however, only one tool that supports this aim. The forest manager should use this tool to determine which set of management options (annual allowable cut, cutting limits, harvesting cycle, silvicultural treatments) are most likely to achieve set management objectives. In order to do this the forest manager must establish a set of management objectives or targets for set time periods (short, medium and long-term plans). These should include objectives for production, environmental protection and social impacts. These are discussed in the next section of the report.

Figure 3. Integrating resource information for yield scheduling. Diagrammatic representation of the system being developed for the Labanan concession.
After (Rombouts, 1998).

5 Objectives for sustainable forest management

5.1 Introduction

5.1.1 The discussion in the previous section **(4.5)** of the requirements for the development of an integrated yield scheduling system identified a requirement for clear objectives for sustainable management of the Labanan concession. It is suggested that the BFMP project should assist Inhutani to establish and document short (1 year) medium (5 year) and long-term (35 year) objectives for the management of the concession. These objectives should address production, environmental and social objectives. The following list represents a suggested minimal set, which should form a starting point for negotiation. It is recognised that the production objectives will be the simplest to agree and implement, whilst environmental and social objectives may require considerable additional research and negotiation and the development of suitable standards.

5.2 Production objectives

- Boundaries and total area of production forest established and protected. The total area should be quantified.
- Annual production of commercial species.
- Annual production of non-timber forest products for local communities.
- Target standing stock of production forest.
- Production methods compatible with certification standards.

5.3 Environmental objectives

- Protection of the soil resource.
- Protection of hydrological resources (river systems)
- Protection of biodiversity.
- Minimise the impact of harvesting operations (roading, felling, extraction)

5.4 Social objectives

- Maintain or enhance the livelihoods of local rural communities.
- Access to agreed forest resources by local communities.
- Sustainable development of rural enterprises and employment in zones outside the area of permanent forest production.

6 Management of the STREK database.

6.1 Background

6.1.1 The statistical and modelling analysis of the STREK database identified a number of issues relating to data management and quality. A list of these issues is presented as Appendix III. The most significant issues are addressed in the following sections.

6.2 Database structure

6.2.1 The structure of the BFMP database is based upon the design for the Growth and Yield Data system located in BPK Samarinda. The structure of the BFMP database had been changed with a number of fields added or deleted. The addition of fields had no implication for compatibility with the GYDS, but the deletion had rendered the tables incompatible with the GYDS. For this reason, data from the December 1998 version of the database could not be validated using GYDS software. This also produced incompatibilities with statistical and modelling analysis procedures developed for use with GYDS data. It was recommended that the structure of the GYDS tables was duplicated in the BFMP STREK database structure, with additional fields appended as required.

6.2.2 The master copy of the BFMP STREK database is currently located in the BFMP office at Tanjung Redeb, as three tables, representing the permanent and dynamic records for each individual tree and a species table. These files are combined to create individual plot files that are used to implement each measurement campaign. These derived tables form the basis of the BFMP data entry system used for the STREK permanent sample plots.

6.2.3 A revised structure was implemented for the master copy of the STREK database by BFMP staff to replicate the design of the GYDS. The modified database tables could then be directly integrated into the GYDS and assessed using GYDS validation procedures. The initial validation identified over 30,000 errors, most of which were related to a transcription error in tree positions. When this was rectified the number of errors were reduced to around 8,000. The GYDS validation procedure assigns data quality flags to tables to identify low quality records. This information is considered essential for further data analysis and growth and yield modelling. Most of the errors remaining in the database relate to diameter measurements, through either imprecise measurement or high buttresses. These problems have already been addressed in the improved field implementation of data collection by BPK and BFMP staff.

6.2.4 The remaining set or errors related to the assignment of species codes to new species in the BFMP database. These were found to be inconsistent with those assigned by the master species database table in the GYDS. It was concluded that the current species assignment does not cause a problem for data processing. It was suggested, however, that there would be advantages in adopting a standardised procedure for assigning reference codes to species, and subsequently species to growth or utilisation groups. It was agreed that if possible species groupings should be based on botanical identification, linked to the national forestry inventory (NFI) code. Further discussion with BFMP staff suggested that this process should be linked with the development of the BFMP inventory database.

6.2.5 The volume equations are currently contained in the species database table consisting of 23 different equations. Some of these differences have resulted from minor typographical errors and it appears that there are 18 distinct equations. Most of these can be checked against publications from the STREK project (Enggelina, 1994; Enggelina, 1998), but a number cannot be verified against original sources. This should be given priority.

6.2.6 The problems of typographical errors and duplication of volume equations in the species table could be removed if the structure of the database was modified. It is suggested that the volume equations should be placed in a separate table linked relationally with the species table. This has the advantage of removing duplication and reduces the probability of data entry errors. This approach is also consistent with that suggested for the BFMP inventory database and it would be possible to use the same table for both applications.

6.3 Documentation

6.3.1 The structure of the STREK database and associated data entry and processing procedures were found to be poorly documented. The database is based upon the GYDS structure, but the documentation for this system was found outdated, as the structures of tables had changed and many data processing procedures were not documented.

6.3.2 The structure of the BFMP data entry system was not well documented. Procedures for integrating data from the entry system with the master database were unclear and were still under development. It was concluded that a very high priority should be given to revising and improving the documentation of both the GYDS and BFMP data entry system. The revisions must document the structure of the database and procedures for data entry, processing and validation.

6.3.3 Several changes had been made to the STREK database and its data, which did not appear to have been documented. This creates difficulty for anybody using the data for analysis as the changes may affect interpretation or processing. This problem identified a requirement to have all changes to the database structure reviewed agreed and fully documented. Modifications or corrections to data should be documented as part of the update procedure.

6.4 Database management

6.4.1 A number of issues relating to database management were identified and discussed with BFMP, Inhutani and BPK-S staff. It was agreed that one person should be identified as the manager for the STREK database.

Audit.

6.4.2 It should be possible for the database manager and data users to trace information back to the original sources of data. This includes datasheets and if necessary intermediate database files such as produced by the STREK project. This has been possible for most information, with the exception of a number of volume equations. The sources of information should be documented and kept updated.

6.4.3 It is also necessary to document the procedures used to obtain, check and process information contained in the database. It is apparent that these have changed since the start of the STREK project and this may have affected the information in the database.

Master copy of database.

6.4.4 There is a requirement to maintain one master copy of the database. It is suggested that this should be located at BPK- Samarinda, with a working copy at Tanjung Redeb and a duplicate in Jakarta.

Backup and archive

6.4.5 Regular backups of the STREK database should be created for both the master database and working copy at Tanjung Redeb. It is suggested that a regular non-volatile backup of the working copy of the database should be created on CD-ROM. These CD-ROMs will create an archive of the database allowing users to revert to previous versions of data if required.

Documenting change

6.4.6 Procedures need to be developed and implemented to document changes to the structure or data of the STREK database. It is suggested that a formal procedure should be implemented to report errors, request changes and to implement these changes. Drafts of forms for these activities are presented as Appendix II.

6.5 Data errors

6.5.1 A number of errors or inconsistencies were identified in the STREK database. These have been documented in Appendix IV along with methods for correction and verification. A series of Foxpro programmes have been written to assist in the verification. The errors should be corrected and verified before the data from campaign 5 are released.

6.5.2 The errors include species coding, calculation of tree volume and basal area and some tree positions. There are also a number of problems associated with identification of poisoned and promoted trees in the thinning trial.

7 Acknowledgements

The author gratefully acknowledges the assistance of BFMP and Inhutani staff in Tanjung Redeb, Labanan and Jakarta and BPK Samarinda staff in Tanjung Redeb and Samarinda who assisted with providing information contained in this report.

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Appendix I.
Species grouping. Growth characteristics.

Species groups were derived by statistical analysis of diameter increment and maximum tree diameter by Dr P.D. Phillips for the development of growth functions for use with the SYMFOR growth and yield simulation model. These same groups have been applied to the statistical analysis of data from the STREK plots in this report. Details of the main groups are reproduced here.

Species Group	Species	Family
1. *Shorea*,	*Shorea hopeifolia*	Dipterocarpaceae
Fast growth rate	*Shorea johorensis*	Dipterocarpaceae
	Shorea leprosula	Dipterocarpaceae
	Shorea parvifolia	Dipterocarpaceae
	Shorea parvifolia ssp parvi.	Dipterocarpaceae
	Shorea parvifolia ssp velu.	Dipterocarpaceae
	Shorea pinanga	Dipterocarpaceae
	Shorea smithiana	Dipterocarpaceae
2. *Shorea*,	*Anisoptera costata*	Dipterocarpaceae
Medium growth rate	*Anisoptera laevis*	Dipterocarpaceae
	Anisoptera sp	Dipterocarpaceae
	Shorea faguetiana	Dipterocarpaceae
	Shorea laevis	Dipterocarpaceae
	Shorea parvistipulata	Dipterocarpaceae
	Shorea parvistipulata ssp alb.	Dipterocarpaceae
	Shorea parvistipulata ssp parv.	Dipterocarpaceae
	Shorea pauciflora	Dipterocarpaceae
	Shorea superba	Dipterocarpaceae
3. *Shorea*,	*Shorea almon*	Dipterocarpaceae
Slow growth rate	*Shorea beccariana*	Dipterocarpaceae
	Shorea confusa	Dipterocarpaceae
	Shorea fallax	Dipterocarpaceae
	Shorea lamellata	Dipterocarpaceae
	Shorea macroptera ssp sandak.	Dipterocarpaceae
	Shorea mecistopteryx	Dipterocarpaceae
	Shorea ochracea	Dipterocarpaceae
	Shorea ovalis ssp ovalis	Dipterocarpaceae
	Shorea sp	Dipterocarpaceae
	Shorea symingtonii	Dipterocarpaceae
	Shorea virescens	Dipterocarpaceae
4. *Parashorea*	*Dryobalanops beccarii*	Dipterocarpaceae
& Dryobalanops	*Dryobalanops lanceolata*	Dipterocarpaceae
	Dryobalanops sp	Dipterocarpaceae
	Parashorea malaanonan	Dipterocarpaceae
	Parashorea smythiesii	Dipterocarpaceae
	Parashorea sp	Dipterocarpaceae
	Shorea longisperma	Dipterocarpaceae

Species Group	Species	Family
5. *Dipterocarpus*	Dipterocarpaceae	Dipterocarpaceae
& Hopea	*Dipterocarpus acutangulus*	Dipterocarpaceae
	Dipterocarpus caudiferus	Dipterocarpaceae
	Dipterocarpus confertus	Dipterocarpaceae
	Dipterocarpus conformis	Dipterocarpaceae
	Dipterocarpus costulatus	Dipterocarpaceae
	Dipterocarpus elongatus	Dipterocarpaceae
	Dipterocarpus fusiformis	Dipterocarpaceae
	Dipterocarpus glabrigemmatus	Dipterocarpaceae
	Dipterocarpus gracilis	Dipterocarpaceae
	Dipterocarpus grandiflorus	Dipterocarpaceae
	Dipterocarpus hasseltii	Dipterocarpaceae
	Dipterocarpus humeratus	Dipterocarpaceae
	Dipterocarpus mundus	Dipterocarpaceae
	Dipterocarpus pachyphyllus	Dipterocarpaceae
	Dipterocarpus palemb. ssp borneensis	Dipterocarpaceae
	Dipterocarpus sp	Dipterocarpaceae
	Dipterocarpus stellatus ssp parvus	Dipterocarpaceae
	Dipterocarpus tempehes	Dipterocarpaceae
	Dipterocarpus verrucosus	Dipterocarpaceae
	Hopea dryobalanoides	Dipterocarpaceae
	Hopea mengarawan	Dipterocarpaceae
	Hopea sangal	Dipterocarpaceae
	Hopea semicuneata	Dipterocarpaceae
	Shorea agamii ssp agamii	Dipterocarpaceae
	Shorea atrinervosa	Dipterocarpaceae
	Shorea exelliptica	Dipterocarpaceae
	Shorea falciferoides ssp glaucescens	Dipterocarpaceae
	Shorea guiso	Dipterocarpaceae
	Shorea maxwelliana	Dipterocarpaceae
	Shorea scrobiculata	Dipterocarpaceae
	Shorea seminis	Dipterocarpaceae
	Sindora sp	Caesalpiniaceae
	Glochidion sp	Euphorbiaceae
6. *Macaranga*	*Macaranga bancana*	Euphorbiaceae
	Macaranga diepenhorstii	Euphorbiaceae
	Macaranga gigantea	Euphorbiaceae
	Macaranga hypoleuca	Euphorbiaceae
	Macaranga indistincta	Euphorbiaceae
	Macaranga pearsonii	Euphorbiaceae
	Macaranga pruinosa	Euphorbiaceae
	Macaranga semiglobosa	Euphorbiaceae
	Macaranga sp	Euphorbiaceae
	Macaranga triloba	Euphorbiaceae
7. *Anthocephalus*	*Anthocephalus chinensis*	Rubiaceae
8. Small trees (Light Demanding)	14 species	
9. Small trees (Shade tolerant)	175 species	
10. Small trees (Other & unknown)	375 species	

Appendix II.
Documentation for amendments to the STREK datbase.

BFMP STREK Database.
Request for data amendment.

Reported by:

Name: ____

Address: ____

____

____

Tel: ____

Fax: ____

Email: ____

Date: ____

Description of problem: (Including justification for modification request)
Suggested modifications: (Include details to clearly identify records to be modified)
Original source of data (if known):

NOTE: Additional information may be included as comments from page 2 of this report.

BFMP STREK Database.
Request for data amendment.

Reported by:

Name: ____________________________

Address: ____________________________

____

____

Tel: ____________________________

Fax: ____________________________

Email: ____________________________

Date: ____________________________

Description of problem: (Including justification for modification request)
Suggested modifications: (Include details to clearly identify records to be modified)
Original source of data (if known):

NOTE: Additional information may be included as comments from page 2 of this report.

BFMP STREK Database.
Request for Approval of Data Amendment.

Reference Number: _________________

Date actioned: _________________

Database tables affected:
Calculated values affected:
Proposed amendments:
Procedures proposed to validate amendments:

Comments and further details.

BFMP STREK Database:
Approval for Data Amendment:

Action:

1. **Referred for comment** (*if required*)**:**

Signature: ______________________ Date: __________
BFMP Team Leader

2. **Comments from review** (*if required*):

Signature: ______________________ Date: __________

3. **Approval for data amendment.**

Signature: ______________________ Date: __________
BFMP Team Leader

4. **Distribution list:**
   BFMP STREK Database Manager
   Inhutani Tanjung Redeb
   Inhutani Jakarta
   BPK Samarinda
   Copy to originator of amendment request

5. **Attachments (copies):**

BFMP STREK Database.
Data Amendment Processing.

Reference Number: _________________

Action:

1. **Backup of current data table:**
   File name and location:

Operator: ___________________________ Date: ___________

2. **Data entry or modification**:

Operator: ___________________________ Date: ___________

3. **Checked by BFMP STREK Database Manager.**

Signature: ___________________________ Date: ___________
BFMP STREK Database Manager

4. **Distribution list (**This document)**:**
   BFMP STREK Database Manager
   Inhutani Tanjung Redeb
   Inhutani Jakarta
   BPK Samarinda
   Copy to originator of amendment request

Appendix III. Data issues in the STREK Database.

Issue	Solution	Required Checks	Comments and Completion
Database structure. Needs to be altered to make it compatible with the GYDS			In progress
Database structure. Volume equations should be stored in a separate table linked by a relation to the species table.			Suggested change
Documentation of the GYDS needs to be updated			BPK-S and DFID requested to update documentation
Documentation is required for the BFMP data entry system			In progress
Documentation of changes to data and database structure	All changes to database structure should be logged with the date of implementation and entered in documentation describing the system. Significant changes to the data should be logged with the date of implementation. An example would be changing the species code of a significant proportion of trees in recording unit		In progress
Data Audit Original data. Need to be able to trace back to original data source			
Data Audit Changes to data. Need to be documented and traced to entry sheets			

Need to identify ONE master copy. At present corrections are not necessarily being propagated between multiple copies of database.			BPK-Samarinda will maintain master copy of database
Require standard procedures for modifying data.			Suggested
Systematic backup and archive regime required	Archive Backup to CD-ROM in Tanjung Redeb		

Appendix IV Data errors in the STREK database

Issue	Solution	Required Checks	Comments and Completion
CDNFI=0 This code has been used in ITREE_P to represent dead trees in campaign 4 and during the new botanical identification. This means that previous measurements for these trees cannot be linked to the correct species or groups.	Revert to previous CDNFI codes. These can be obtained from backup copies of ITREE_P.	CDNFI =0 removed from species table Species codes have been correctly updated in itree_p. This can be checked against the list of trees with species code = 0 **..\db_bfmp\checks\nfi0.dbf** **..\db_bfmp\checks\check nfi.prg**	In progress
CDNFI=4381 CDNFI=4569 These codes are present for two trees in the database, but are not present in the species list specie.dbf. The majority of these codes have been corrected leaving only two trees.	Replace these codes with CDNFI=6998 Check species of the large tree in field Plot: BFMPBER 1 3 Tree: 2-147 The other tree is small and now dead	Check for CDNFI 4381 and 4569 Check CDNFI values for BFMPBER 1 3, tree 2-147 BFMPBER 4 9, tree 1-450	In progress
CDNFI=2128 *Shorea johorensis.* The volume equation is incorrect in SPECIES table	Correct coefficients A=0.1834 B=-3.0820 C=17.5734 Volume estimates to be updated in dynamic file	Check against updated SPECIES table	Complete

SPECIES CDNFI Codes Codes > 7000 do not match GYDS master species database. Details are contained in ERRORDB after GYDS validation	Document differences and where possible replace with codes present in GYDS. Where species is not present, use GYDS rules to select new CDNFI codes. Update GYDS Species table if required	Use GYDS validation procedure to check species.	Referred to BPK-S
Volume Calculations Several errors in database (Documented elsewhere)	Check against original source data (Inhutani/ Cirad)		In progress
TREEVOL=0 200 records with TREEVOL = 0	Recalculate all tree volumes, Exclude if diam <10cm, set to NULL		In progress
BASAL Area = 0 1 record	Recalculate Basal area Exclude if diam <10cm, Set to NULL		In progress
DIAM=0, Campaign 4 42 records with DIAM = 0	17 records can be updated from field sheets. Remainder need to be checked after Campaign 5. Set any remaining values to NULL	Check after campaign 5 ..\db_bfmp\checks\diam0.dbh **..\db_bfmp\checks\check diam0.prg**	
999 in remarks, and DIAM <999 All of these trees had been assessed as dead at the previous survey.	No action at present	Check after campaign 5 **..\db_bfmp\checks\rem999.dbh** **..\db_bfmp\checks\check 999.prg**	
-ve x_ru, y_ru, x_plot, y_plot. Values exceed correct values	Should have been corrected during processing of campaign 5	Scan itree_p for out of range values	In progress
Tree positions contain NULL or 0	Tree positions should be checked against original STREK maps and data. Zero or Null values should be replaced	Check after campaign 5 **..\db_bfmp\checks\posnull.dbh**	Some zeros will be valid

Tree positions BFMP 4 1, RU-4 All trees have changed position when compared with STREK maps and database.	Check against STREK maps and in the field.	STREK data were incorrect, BFMP data and maps have already been corrected and field checked	Completed and checked
Dead ingrowth during Campaign 4 6 trees were first recorded in campaign 4 having a diameter code indicating that they were dead. These cannot be validated within the GYDS	Data need to be removed from ITREE_D	Tree numbers recorded in **..\db_bfmp\checks\deadingrowth.dbh** **..\db_bfmp\checks\remove dead ingrowth.prg**	
Cannot identify Promoted trees for thinning trial	Crop trees for PCT treatment marked on maps. Tree numbers should be recorded and the transferred to database		
Cannot identify poisoned trees for thinning trial	Original STREK temporary files contain data on poisoned trees. These data need to be processed to extract information and merged with ITREE_P.	Tree numbers in **..\db_bfmp\checks\poisoned.dbf**	Poisoned trees should not be used to calculate estimates of diameter increment.
Data describing logging and skidding database for RKL-4 6 trees have different data	Compared with data compiled from STREK temporary files	**..\db_bfmp\checks\logging damage.dbf** Compare with **..\db_bfmp\checks\check logging damage.prg**	
Regeneration data not available	Check datasheets Discuss with CIRAD		
STREK book mentions poisioning trees in RKL4 (Pg. 184) Which trees?	Cannot find information in field sheets or data files. Check with STREK/ CIRAD	Trees that have died through poisoning can be identified from database. When checked in field it was found that the trees had been poisoned. The effectiveness was low, as many trees were still alive. This was confirmed	

		in the database, where it was found that many trees appeared to have been assessed as living after previously been found to have died.	