

Applying SYMFOR for Forest Management

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Introduction.

SYMFOR is a individual tree growth simulation model that is applied as a tool for the analysis of growth and yield data from permanent sample plot series (PSP/PUP). The simulation model can be used to predict the growth and yield of an area of forest, based upon *representative* PSP data. This presentation will discuss the steps required to apply SYMFOR as a tool for growth and yield prediction supporting improved forest management in Indonesia.

SYMFOR simulates the growth of individual trees through the simulation of the processes of increment growth, mortality and recruitment. These model components include stochastic (random) events. For this reason, replicate runs must be completed and the results of these simulations subjected to statistical analysis.

SYMFOR requires:

- PSP/PUP data for calibration. (Currently completed using STREK data)
- PSP/PUP data for initialisation of individual runs (1 ha plots)
- Statistical analysis to interpret results from each series of simulations.

SYMFOR is a *tool* that is used to assist forest management. The applications that will be demonstrated during the workshop include:

- Prediction of the growth and yield of an area of forest following logging.
- Prediction of the status of the forest at periods after the application of logging or silvicultural treatments to the forest.

The results from the application of SYMFOR to PSP data provides information to support forest management and the decision making process. In order to do this, the results need to be interpreted by forest managers.

Application of SYMFOR.

The application of SYMFOR requires a number of data processing and analysis activities. These will now be discussed. The provision of high quality information to support forest management, requires the following steps:

- Data collection and preparation.
- Extraction of data for statistical analysis and model initialisation
- Statistical analysis of PSP results
- Statistical analysis of model results
- Interpretation.

Data collection and preparation.

The collection and preparation of data requires the establishment of PUP using standardised field procedures linked to procedures for data quality assessment of the resulting datasets. The growth and yield data clearing house established by BPK-Samarinda for PSP data in Kalimantan provides a model for this activity. SYMFOR has been designed to work with the Growth and Yield Data System (GYDS) and this will be used for the training sessions using data from the STREK project in the Labanan concession of PT Inhutani I in East Kalimantan.

Data collection.

Data collection now uses standardised procedures designed by the EU- Berau Forest Management Project and jointly implemented by Inhutani, BFMP and BPK-Samarinda. These procedures emphasise the need for standardised data collection in the field. Data are entered into a database for each plot and then subjected to data quality assessment. Any problems in the data that are identified

during the quality assessment are then checked in the field before new measurements are merged into the master database which is compatible with the growth and yield data system.

Data validation.

The master STREK database is stored in the GYDS format by the Berau Forest Management Project. A copy is maintained by BPK-Samarinda. The application of a standard format enables the application of the data validation procedures developed by the data clearing house. The data from the STREK project have been validated using this system. This validation identifies potential problems in the dataset that are usual associated with measurement errors. A common example is very large diameter increments $>5 \text{ cm annum}^{-1}$ or large negative increments $< -0.5 \text{ cm annum}^{-1}$. These data are considered unreliable and have been checked again, and in most cases have been excluded from the calibration of growth functions. Individual diameter measurements can however still be used for initialisation of individual model simulations.

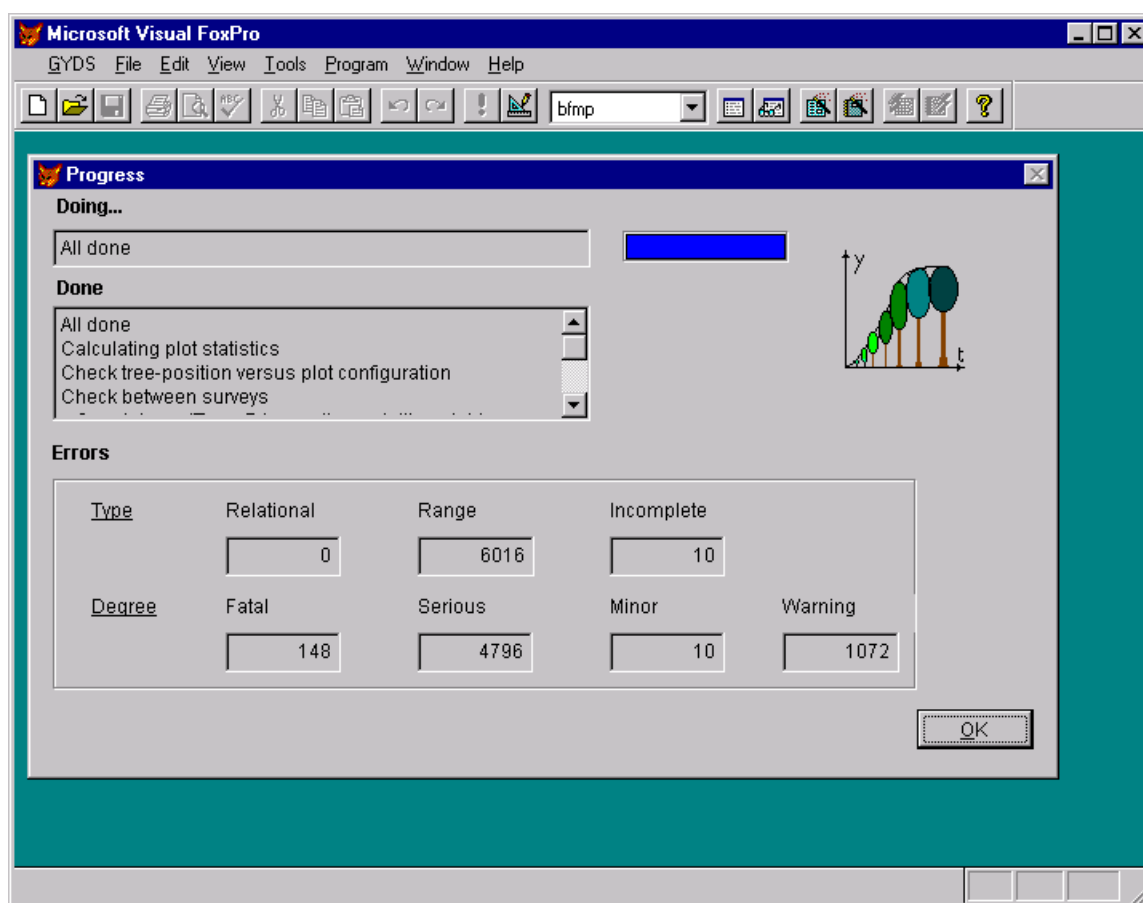


Figure 1. Data validation screen from the Growth and Yield Data System. Results of the validation of the STREK database from PT Inhutani I in East Kalimantan. Data were analysed from the first four measurement campaigns of the project.

Data extraction.

Data are extracted from the Growth and Yield Data System for statistical analysis of measured data, and preparation of initialisation (input) files for each simulation run. The data are extracted using a set of programmes written for Microsoft Visual Foxpro. The resulting data files are then available for subsequent data analysis or as input for simulation models including SYMFOR. The clearing house has the advantage of providing information in a standard format that is compatible with these analysis functions using data that has already been subjected to detailed quality control.

The STREK logging trial was designed with four experimental treatments, an unlogged control, conventional logging and reduced impact logging with diameter limits of 50 and 60 cm. Each treatment has three replicate 4 hectare plots with each plot being subdivided into 4 1 hectare recording

units. This gives 48 plots for analysis each having 4 measurement campaigns over a period of eight years.

The screenshot shows the Microsoft Visual FoxPro interface. The main window displays a data table with the following columns: Treenumber, Dbh, Speciesgrp, Xposn, and Yposn. The data is as follows:

Treenumber	Dbh	Speciesgrp	Xposn	Yposn
100	93.900	6	5.100	2.500
101	17.500	5	6.700	3.000
102	13.100	2	1.200	4.600
103	13.100	6	9.000	6.200
104	40.900	5	8.600	7.400
105	11.300	6	4.900	11.000
106	10.300	6	7.900	11.400
107	15.800	6	9.000	12.000
108	11.600	6	6.100	12.600
109	20.700	2	7.000	15.300
111	23.900	6	7.500	22.000
112	16.200	6	8.500	24.500

The status bar at the bottom indicates: R1p01ru1c3 (d:\g&y_data\db_bfmp\sy, Record: 1/489 Exclusive)

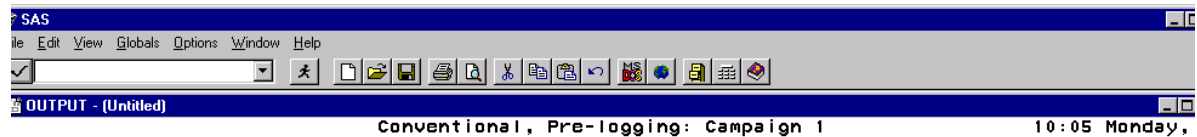
Figure 2. Production of initialisation files for SYMFOR by the Growth and Yield Data system. Data are stored as Visual Foxpro data tables.

Statistical Analysis of STREK data.

The data extracted from the STREK logging trial have been subjected to preliminary statistical analysis. The data have been processed by calculating the total basal area, volume and number of stems for each 1 hectare recording unit. The mean and standard error of these have been calculated for each experimental treatment and campaign date. Data were subdivided by species group and size class. The species groups were derived by growth rate and tree size for use in the SYMFOR simulation model and are presented in Appendix 1. Tables of the average basal area, volume and number of stems have been provided for the conventional and 60 cm reduced impact logging treatment, for the first, second and fourth measurement campaign. These represent the pre-logging status of the plots, and intervals two and four years post-logging. These data can be used for analysis of the logging trials. Similar data (excluding the standard errors) are presented as Excel spreadsheets. The volumes represent total stem volume (over bark) and were calculated using the STREK volume equations.

The following questions can be answered using the tables or spreadsheets.

- Which species groups were harvested during the logging operation?
- What volume was extracted?
- What is the volume increment since harvesting? This should be expressed as a mean annual increment, calculated as (net volume increment)/(measurement interval, years).
- Which species groups are growing fastest?
- What is the net commercial volume increment?



Volume	Diameter Class													
	10-29.9		30-49.9		50-59.9		60-69.9		70-79.9		80+		All diam.	
	Mean	±s.e.	Mean	±s.e.	Mean	±s.e.	Mean	±s.e.	Mean	±s.e.	Mean	±s.e.	Mean	±s.e.
Shorea, Fast	2.6	0.7	4.4	0.8	6.4	1.3	4.7	0.2	11.1	4.1	24.5	2.7	24.3	5.0
Shorea, Med	1.3	0.3	2.7	0.7	4.6	1.6	6.3	0.9	6.8	0.4	22.8	6.5	22.9	6.7
Shorea, Slow	2.3	0.9	3.7	1.1	6.1	1.6	10.3	5.0	17.0	4.3	38.2	15.6	37.6	12.4
Dryobalanops	2.5	0.3	4.6	0.7	5.3	1.0	11.2	5.1	12.1	2.2	63.1	11.0	71.2	15.2
Dipterocarpus	12.8	1.9	18.3	4.4	10.3	1.7	21.8	3.2	18.7	2.7	23.0	5.1	92.3	12.2
Macaranga	0.9	0.3	1.7	0.5	.	.	.	.	.	.	.	.	1.8	0.5
Anthocephalus	.	.	.	.	3.1	.	.	.	.	.	.	.	3.1	.
Small (Light)	0.6	0.2	0.9	0.2	2.8	0.3	.	.	.	.	.	.	1.2	0.5
Small (Shade)	16.8	1.7	12.9	2.7	6.1	2.4	8.6	1.3	.	.	7.8	0.1	37.1	6.5
Small (Other)	42.7	1.3	44.5	3.7	12.7	2.6	14.0	1.7	8.6	1.2	13.4	2.8	126.2	7.2
All Species	81.7	3.1	90.0	6.7	38.4	4.8	40.2	5.8	43.2	4.4	118.1	15.7	411.6	14.8

Figure 3. Statistical analysis of PUP data from the STREK plots. Mean values of total stem volume (Over bark) for the conventional logging treatment. Data are presented as the mean ± standard error. The standard error is calculated at the standard deviation divided by the square root of the number of plots. (σ/\sqrt{n}).

In order to calculate the commercial volume increment it is necessary to convert from total stem volume to potential log volume. This can be done assuming the following:

- 80 % of the stems with a diameter greater than 60 cm are harvested.
- 50 % of the stems in the 50 – 60 cm size class will be harvested.
- Commercial log volume is 50 % of whole tree volume.

Modelling using SYMFOR.

SYMFOR has been applied to predict the structure of the PSP plots 35 and 70 years following logging. The plots for the conventional and 60 cm reduced impact logging treatments have been used to create initialisation files for SYMFOR. Data from campaign two were selected to represent the condition of the forest immediately following logging. Twelve 1 hectare plots were prepared for each treatment and each plot was used in ten replicate simulations using SYMFOR. SYMFOR was programmed to output information about all living trees at either 35 or 70 years following logging. These data were then analysed using the same procedures as used for the analysis of plot measurements. The replicate simulations were performed using the multi-run facility of SYMFOR to generate database tables for subsequent data analysis (Fig. 4).

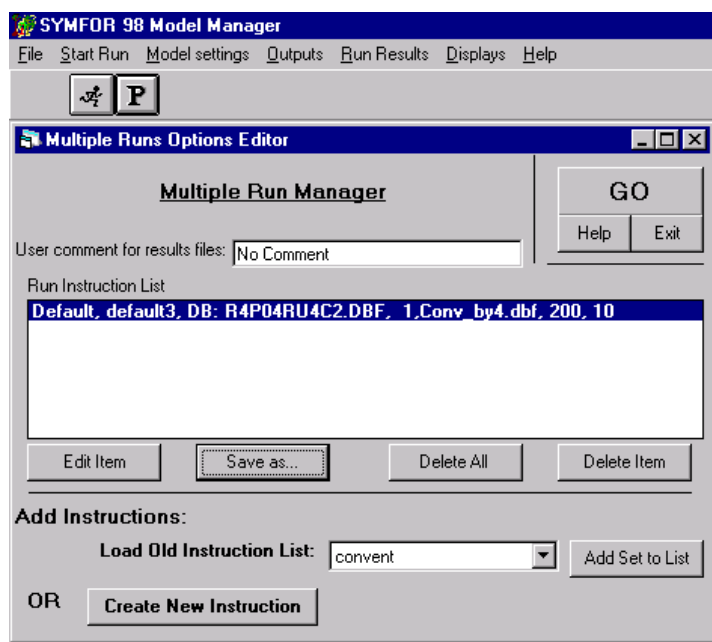


Figure 4. Multi-run interface for SYMFOR.

Statistical analysis of the results from simulations using SYMFOR provides tabular output in the same form as for the analysis of measured PSP data. The same approaches can thus be used to interpret results from model simulations (Fig. 5).

Volume	Diameter Class													
	10-29.9		30-49.9		50-59.9		60-69.9		70-79.9		80+		All	
	Mean	ts.e.	Mean	ts.e.	Mean	ts.e.	Mean	ts.e.	Mean	ts.e.	Mean	ts.e.	Mean	ts.e.
Shorea, Fast	4.5	0.7	5.1	0.7	6.5	0.9	4.7	0.2	13.3	6.6	24.3	4.8	27.4	5.0
Shorea, Med	1.4	0.2	2.8	0.7	3.2	0.2	11.5	2.5	6.3	0.3	22.0	6.0	23.9	6.6
Shorea, Slow	0.9	0.3	2.2	0.6	4.3	0.6	4.3	.	9.6	2.4	23.7	5.9	15.5	3.9
Dryobalanops	2.1	0.2	3.3	0.5	6.0	0.7	5.0	.	8.6	1.8	20.7	5.1	24.9	5.0
Dipterocarpus	11.6	1.1	17.1	4.3	11.2	1.9	10.9	2.6	10.0	2.3	19.4	5.1	55.8	8.5
Macaranga	1.0	0.2	1.9	0.8	2.4	.	.	.	.	.	.	.	2.2	0.6
Anthocephalus	0.3	0.1	.	.	3.5	.	.	.	.	.	.	.	0.6	0.3
Small (Light)	0.9	0.2	0.7	0.2	2.8	0.5	.	.	.	.	.	.	1.5	0.4
Small (Shade)	14.8	1.1	12.1	2.6	6.2	1.9	8.6	1.8	.	.	6.8	0.3	34.0	5.7
Small (Other)	33.3	1.3	40.4	3.7	11.5	2.4	13.3	1.9	7.4	1.0	12.2	2.8	108.9	6.6
All Species	70.7	2.2	83.2	7.1	36.8	4.2	24.4	4.7	19.0	3.1	62.9	7.5	294.9	15.2

Figure 5. Statistical analysis of simulation results from SYMFOR for the conventional logging plots after a period of 35 years.

Using the results from the simulation model it is possible to extend the interpretation of results from the PSP plots. The simulation model provides a method to predict the status of the stand at set periods after logging or other silvicultural treatments. The results from the two sample applications can be used to answer questions such as:

- What was the commercial volume increment over the period of the simulation?
- What is the commercial volume that can potentially be harvested 35 years following logging?
- How would these results change if the length of the cutting cycle is extended, for example to 70 years.

Conclusions

This presentation has demonstrated one basic application of the SYMFOR growth and yield simulation model for forest management. SYMFOR was applied using PSP data to make predictions of the likely future status of the stand at set intervals following logging. The model should be used as a tool supporting the analysis of PSP data for forest management. The key features of such an approach are:

- PSP data are used to describe the status of the stand at the start of the simulation period (e.g. immediately following logging).
- SYMFOR is used to predict the future structure of the stand after a period of regrowth.
- Data from PSP measurements and simulation results are analysed using the same approaches to support management decisions.
- In more complex applications, SYMFOR can be applied to investigate other silvicultural treatments, including logging.

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

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

