

MODELLING ALTERNATIVE SILVICULTURAL PRACTICES WITHIN SYMFOR – Setting the model and interpreting the results.

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1. Introduction

1.1 Introduction

SYMFOR is an individual based tree growth model which has been developed for use in Indonesia. It can be used to model the growth of a stand of forest based upon each individual tree's size (dbh), species and position relative to its neighbours. The positional element of SYMFOR allows inter-tree effects to be represented and therefore the model can be used to examine the effects upon growth of (artificially) altering the structure of the forest. Thus the model can be used as a forest management tool; to compare alternative silvicultural treatments with regard to initial timber yield, and condition and regenerative capacity of the forest thereafter.

1.2 Growth and Yield Modelling for Sustainable Forest Management

From an ecological viewpoint, sustainable forest management (SFM) requires that the species composition and structure of an area of forest is not altered beyond a point from which it cannot recover, within a given time period. In practice defining this point is very difficult. The simple assumptions regarding annual increment which form the basis of the Indonesian TPTI system have been used to calculate how much timber can be removed from an area of forest, without irreversibly altering its structure. However these calculations relate only to the volume of timber to be extracted, and not to the impact of the extraction activities upon the remaining stand.

It is therefore desirable to observe the impact of the whole extraction exercise upon the species composition and structure of the remaining stand. This will allow an estimate to be made as to how long it will take the forest to regain its original condition. In addition, if it is possible to reduce the impact of the extraction exercise, this may reduce the forest's recovery period.

SYMFOR is a modelling tool which can be used to simulate the full impacts of harvesting upon the remaining trees in a stand of forest. These impacts include; areas damaged when the felled tree falls over, the area damaged whilst positioning the bole for skidding, mortality of all trees and soil compaction in skid trails. After taking into account these impacts, the growth of the altered stand structure is modeled according to the new environmental conditions, and a prediction can be made as to when the stand will regain its original condition. (Or, more realistically, when the stand will be worthwhile extracting timber from again).

It is a simple exercise to reduce the amount timber extracted, or the related damage caused within SYMFOR. These both result in a greater number of living trees in the remaining stand, and therefore different growth conditions and recovery period. In this way, SYMFOR can be used to examine how any level of extraction and damage will affect the rate of recovery of the remaining stand. It can therefore be used to define and plan ecologically sustainable forest management practices.

From an economic viewpoint, SFM requires that (over a given time period) the income gained from the sale of timber and other products, is greater than the total expenditure committed in producing these products. More realistically, most concession holders demand an income 15-20% above their expenditure, to compensate for the risks inherent in forestry.

In order to assess the sustainability of any system of forest management, it is therefore necessary to weigh the costs of production against the income gained, again over a given time period. Whilst two alternative approaches to harvesting may yield the same amount of timber (and therefore raise the same income), the high costs involved in performing one may mean that it is not economically sustainable (over the time period in question), even if it is the most ecologically sustainable.

SYMFOR is a Growth and Yield Model, not a model of forest concession economics. It can therefore be used to directly assess the ecological sustainability of a management system. By providing information on the volume and class of timber produced under any management system, it also provides information essential to conducting an analysis of the economic sustainability of that system. Because timber yields can be estimated over the short, medium and long term, this facilitates using SYMFOR to provide input for economic analyses over these time periods also.

This report shows how to use SYMFOR to simulate the effects of different silvicultural practices upon a stand of forest. It also demonstrates to new users the range of data which can be output by SYMFOR, and which can be used in defining and assessing the sustainability of any system of forest management.

2. Objectives of this Document

The objectives of this document are

To outline the role of Growth and Yield Modelling in Sustainable Forest Management

- To outline the approach taken to modelling forest growth with SYMFOR, and to relate this to forest management
- To explain the structure of SYMFOR
- To break the model down into its component parts, explain how each works and how it can be used to represent various silvicultural practices
- To demonstrate the flexibility of SYMFOR in modelling alternative silvicultural and forest management activities
- To present some illustrative results which demonstrate the applications of SYMFOR
- Overall, to form an introductory guide for new users of SYMFOR, and a reference document for future use

2.1 Who is this Document for?

This document has been written for anyone who is interested in using a tool (SYMFOR) to assist them in making decisions relating to tropical forest management.

It is intended to introduce people to the SYMFOR modelling framework, and to demonstrate how it works and what it can be used for. Once a new user has this knowledge, he will be able to develop his own applications for SYMFOR and use it to make predictions relating to forest growth and yield under a wide range of alternative scenarios.

The document assumes a basic knowledge of forest management and silviculture, basic computing skills, but no previous experience of modelling.

3. What do we want to model?

Models such as SYMFOR are of value to forest management (planning) because they allow the user to explore the impact upon the forest of a wide range of treatments, both now and in the future. These treatments can be realistic or theoretical, or somewhere in between. Examples are given in Table 1.

Current / Realistic Treatment	Theoretical Treatment
RIL with minimum felling dbh >50 or >60	RIL with perfect directional felling
TPTI with minimum felling dbh >50 or >60	Skid trails 2m wide
Branched skid trails	An upper limit to the number of stems to be removed per ha

Table 1: Some current/realistic and theoretical forest management treatments which SYMFOR can perform. The realistic/theoretical split refers only to what is likely to be achievable in the field (rather than to what SYMFOR can accurately model).

The reasons why we would want to model realistic treatments are obvious

- to estimate the timber yield achievable from a given area of forest
 - to observe the amount of damage done during harvesting
- to gain an idea of how long it will take before another harvest is desirable (or economically feasible).

It is less obvious why we would want to model a treatment which is (at least at the current time) unachievable in practice, for example 2 m wide skid trails. This approach is desirable however, as it allows the user to observe how changes or improvements in a treatment will influence the structure of the stand in the future.

For example: if we could keep skid trails to 2m wide, would it have a noticeable impact upon future commercial harvest? If the answer is yes, this suggests that it is a worthwhile management objective to reduce skid trail width. SYMFOR could therefore be re-run, creating skid trails 4m wide during harvesting (much more achievable in practice), to see if the benefits are still evident. In this way the modelling of a theoretical treatment has indicated what is desirable, before refining it to look at what is achievable.

The benefits of this approach are also evident with the more readily achievable theoretical treatments (such as directional felling), given in the table above.

It is recommended that new users take this approach to modelling – start with extreme values to get a feel for the model and the effects of the practice being modelled, then work back to what is realistic.

3.1 'What if....?' scenarios

An effective approach to using SYMFOR to evaluate the desirability of different management practices is to develop a series of 'what if' scenarios, and compare them with a base scenario in each case. Examples are given below

- What if the minimum diameter at breast height (dbh) for felling is increased from 50 to 60 cm? How will it affect yield today? How will it affect the stand structure / commercial yield in 35 years?
- What if the felling cycle is increased to 40 or 50 years? How will it affect the stand structure / commercial yield compared to year 35?
- What if I require a set volume of timber from the forest today. How will logging RIL style affect the future stand compared with TPTI style?
- What if there is a maximum number of stems allowed to be felled per ha? How does this affect timber yield in year 0 and the stand structure / commercial yield in year 35?

In each case it is essential to compare, at the same point in time, two (or more) different treatments performed upon the same stand of forest (ie the same set of input data).

Each user will be interested in a different aspect of the treatment and the remaining stand structure - for example, you may want to know

- the volume of timber harvested,
- what area has been damaged by skidtrails,
- the number of individuals of any one species group left standing,
- the total Basal Area (BA) in the stand 20 years after logging
- the number/volume of trees which have died naturally over that period.

SYMFOR can be used to output data on all trees (standing, felled or killed) in the stand, as well as the area covered by skidtrails. This data can be output at any point in time (ie at the end of any year), so that the growth of a stand and the regeneration of damaged areas can be followed through time, or observed at any particular point in time. This data can be used to calculate, for example, how many years after logging there will be a sufficient volume of commercial timber in the stand to justify a second harvesting. This demonstrates a direct forest management application of SYMFOR.

How to output and interpret such data is covered in Sections 6-8.

Swappable function:	Module(s)	Explanation and parameter setting
plotparams	plotparams1	<i>sets the parameters (ie shape and size) of the plot in which the modelled forest is growing. Generally this will be 100x100m – the default values.</i>

Swappable function:	Module(s)	Explanation and parameter setting
calc_treatment	calc_treatment	<i>allows the user to set the year in which the first logging will take place, and the length of the logging cycle</i>

Swappable function:	Module(s)	Explanation and parameter setting
treatment	TPTI RIL	<i>the TPTI and RIL modules choose the style of logging which the user wants to perform, although the two are essentially the same. No parameters need to be set here</i>
	TPTJ	<i>select this if you want to ‘selectively log and replant in strips’. the module allows the removal of all vegetation in strips , tending and replanting (set the width of strips, tending and replanting details in the ‘createstrips’ Swappable function</i>

Swappable function:	Module(s)	Explanation and parameter setting
createstrips	createstrips1	<i>available only if the TPTJ treatment has been chosen. The user can set here</i> <ul style="list-style-type: none"> -width of the cleared strips to be created -the distance between them -the length of time they are to be tended -the species to be replanted -the utility group to which the replanted species should be assigned

Swappable function:	Module(s)	Explanation and parameter setting
logqualify	qualify1 TPTJqualify	<p><i>allows the user to select which trees are of sufficient size, quality and species/utilisation group to harvest. This involves setting the minimum dbh of trees to be felled in each utility group (usually 50cm for groups 1-4, 500cm for groups 5-10 ie those not to be felled). See Section 4.3.</i></p> <p>Every tree has a number attached to it which represents its (commercial) quality – the ‘quality limit’ parameter is used to deselect PCTs from logging because of poor quality/defects. Setting quality limit to 0.3 means that 30% of the PCTs will not be felled.</p> <p>selects trees to be harvested under TPTJ. Allows setting of min dbh as above, but no quality limit as all stems in a strip are felled</p>

Swappable function:	Module(s)	Explanation and parameter setting
logselect	select1	<p><i>here it is possible to specify a maximum number of stems to be felled in any logging (nlogmax), as well as a maximum and minimum volume of timber to be felled. (maxextract and minextract respectively)</i></p>

Swappable function:	Module(s)	Explanation and parameter setting
felling	undirectional directional	<p><i>the felling Swappable function simulates the damage caused by a felled tree</i></p> <p>SYMFOR selects a random fall direction, no parameters need to be set</p> <p>here the user can set the direction in which trees are to be felled, relative to the position of the skid trail. An exact direction can be chosen, or a range specified.</p>

Swappable function:	Module(s)	Explanation and parameter setting
planskidtrails	straight branched	<p><i>planskidtrails earmarks the areas which are to be affected by skidtrails</i></p> <p>the skidtrail forms a direct line from the stump of every felled tree a point on the edge of the plot. The user can choose this ‘accesspoint’ by setting the parameters offered – the default values are recommended.</p> <p>here, a straight skidtrail is created between the accesspoint and the felled tree furthest from it. Where suitable, all other skidtrails will branch off this one, thus reducing the total area of skidtrails. The ‘joinangle’ parameter sets the angle at which a new skidtrail will join onto a skidtrail which has already been created</p>

Swappable function:	Module(s)	Explanation and parameter setting
calcskidcorners		<i>when a bole is skidded round a corner a triangular area of damage is caused where the log 'cuts' the corner eg where one skid trail joins another. calcskidcorners creates this triangle of damage, which is dependent on the length of the log being skidded</i>
	nocorners	if nocorners is chosen this damage area is not created
	sharpcorners	if sharpcorners is chosen the damage area is created there are no parameters to set in either case

Swappable function:	Module(s)	Explanation and parameter setting
dragdamage	dragdamage1	<i>this module simulates the effect of dragging a felled stem into line with a skidtrail. A triangle of complete damage but no soil compaction is created. SYMFOR creates the damage area dependant on the size of the bole being skidded</i>

Swappable function:	Module(s)	Explanation and parameter setting
skidprepdamage	skidprepdamage1	<i>a felled and bucked stem often has to be manoeuvred by the bulldozer into a position from which it can be skidded, for example with one end elevated. This damage caused by the bulldozer is represented by a circle of damage around the stump of the felled tree.</i> the parameter ' skidprepradius ' allows the user to choose the radius of this circle of damage

Swappable function:	Module(s)	Explanation and parameter setting
skidtrails	skidtrails1	<i>the width of a skidtrail depends primarily on the width of the skidders front blade</i> here the user can set the width of all skidtrails to be between 1m and 30m

Swappable function:	Module(s)	Explanation and parameter setting
skidtraildamage	skidtraildamage1	<i>this Swappable function is used to specify what damage is caused within the skidtrail (whose width is set in skidtrails1, above)</i> the user can select a dbh (maxdbhdamage) above which no trees will be damaged by the skidtrail. The ' damageprob ' parameter represents the probability of a tree below the maxdbh being damaged. It is recommended that this is set to 1, so that all trees within the skid trail, with dbh below the maxdbhdamage are killed.

Swappable function:	Module(s)	Explanation and parameter setting
calcages		<i>this 'calculates the age' of all aspects of the forest (trees, damaged areas), increases their age each year, and decides whether a damaged area is still 'damaged' or not. If not, recruitment and growth can resume according to the settings within the ecological model</i>
	calc_ages1 calc_ages2	the parameter 'skidpersist' stipulates how long a skidtrail remains before that area of damage becomes unrecognisable from the surrounding forest. Whilst a skidtrail still persists, recruitment and growth are impaired, and the area is recognisable for use as a skidtrail in a subsequent logging cycle. 'logpersist' – as above, but for an area of damage caused by a felled tree
	calc_agesTPTJ	not yet calibrated, therefore not in use

Table 2: Explanation of SYMFORS Swappable functions, Modules and Parameters

4.3 Note on 'dbhthreshold'

Deciding exactly which trees are to be felled is possibly the most important decision in sustainable forest management. The parameter 'dbhthreshold' allows the forest manager to specify the minimum size of stems to be felled in each utility group. The window below is where the dbh thresholds can be set –

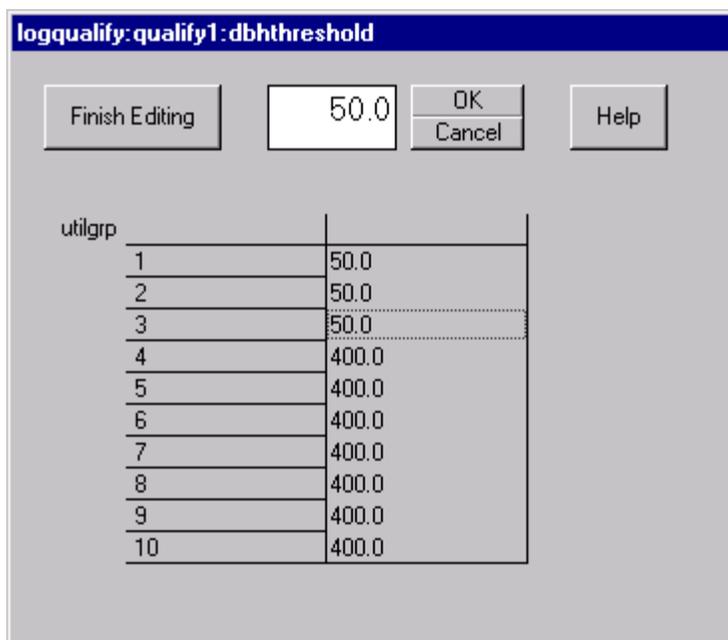


Figure 1: Window for setting the 'dbhthreshold' parameter

In the window above, all stems above 50cm dbh in ‘utilgrp’s 1,2 and 3 will be selected for felling. Stems in utilgrps 4 –10 will only be felled if they are over 400cm dbh. That is, we do not want to fell any trees in these groups so the dbhthreshold has been set unrealistically high.

4.4 Utility Groups and Species Groups

It is important not to confuse these, as they are similar, but distinct. Every tree in SYMFOR belongs to one utility group and to one species group

- **The utility group dictates whether the tree is considered as commercial or not.**
- **The species group dictates how the tree grows.**

The utility groups used are the BFMP Commercial Groups, see table 3.

Utility Group	Characteristics of members	Commercial?
1	Merantis	Yes - all are Dipterocarps
2	Fast growing other dipterocarps	
3	Slow growing other dipterocarps	
4	Non-dipterocarp major commercials	Possibly – depends on circumstances
5	Non-dipterocarp minor commercials	No
6	Protected	
7	Non-commercials, unknown, others	

Table 3: BFMP Commercial Groups (Rombouts, 1998)

The species groups have been developed by analysis of the growth characteristics of all tree species found in the Berau region. Species with similar growth characteristics have been grouped together. See Table 4.

Species Group	Growth characteristics of members	Main species
1	Fast growing, large, light lovers	Shoreas
2	Medium growth rate, large, light lovers	Shoreas
3	Slower growing, medium sized, light lovers	Shoreas
4	Fast growing, med-large trees, shade tolerant	Parashoreas, Dryabalanops
5	Slowish growing, large trees, shade tolerant	Dipterocarpus, Shoreas
6	Very fast growing pioneers	Macarangas, Glochidion
7	Fast growing, small trees, damaged forest	Anthocephalus
8	Small trees, recruit in light areas	
9	Small trees, recruit in shade areas	
10	Small trees, average or indeterminate recruitment	Unknown, others

Table 4: The SYMFOR Species Groups (Phillips and van Gardingen, 1999)

5. How can different silvicultural practices be modelled?

The wide range of alternative management practices which can be modelled within SYMFOR have been grouped under three broad headings. These are all found within the Silvicultural Options drop down window.

- TPTI
- RIL
- TPTJ

None of the above treatments is a fixed prescription – either in the forest or within the model. Therefore the user is free to set the parameters (eg length of felling cycle, skid trail width) to be used under any treatment, and is encouraged to observe the impacts of altering these parameters on the forest stand structure, and its growth and yield.

The following two sections show the modules and parameters settings which should be used to represent TPTI (conventional) and RIL logging respectively. The user should refer to Table2 (above) for an explanation of what factor(s) each module and parameter influences. These settings are intended as a starting point only, to demonstrate the basic differences between modelling conventional and RIL within SYMFOR.

5.1 TPTI (conventional) Logging

The following table shows the suggested settings for initial use in modelling conventional logging.

Swappable function	Module	Parameter Settings
plotparams	plotparams1	xplotmax 100 yplotmax 100 xplotmin 0 yplotmin 0 nxgrids 10 nygrids 10
calc_treatment	calc_treatment	Firstlogging - forest managers decision loggingcycle - forest managers decision
treatment	TPTI	pre-set by SYMFOR
logqualify	qualify1	dbhthreshold (see section 3.3) qualitylimit 0.3
logselect	select1	nlogmax 1000 maxextract 500 minextract 0.0
felling	undirectional	random direction chosen by SYMFOR
planskidtrails	straight	accesspointx 50.0 accespointy 0.0
dragdamage	dragdamage1	pre-set by SYMFOR
skidprepdamage	skidprepdamage1	skidprepradius 5.0
skidtrails	skidtrails1	skidwidth 5.0
skidtraildamage	skidtraildamage1	maxdbhdamage 30.0 damageprob 1.0
calc_ages	calc_ages2	skidpersist 40 logpersist 40

Table 5: Suggested settings for conventional logging

- **The main characteristics of conventional logging are non-directional felling and unplanned skid trails.** These factors are modelled in SYMFOR by choosing the modules for ‘undirectional’ felling (trees fall in a random direction relative to the skid trail), and ‘straight’ skid trails – every felled tree is skidded directly to a common point at the edge of the stand.
- The additional damage caused to the residual stand during harvesting is represented by the modules skidprepdamage1 and skidtrails1. For conventional logging the area affected by these is likely to be large and therefore the parameters should be set to high values (in comparison with RIL). The modules dragdamage1 and skidtraildamage1 can also be used to fine tune the amount of damage caused/area affected by skidding.

5.2 RIL Logging

The following table shows the suggested settings to be used to model RIL.

Swappable function	Module	Parameter Settings
plotparams	plotparams1	xplotmax 100 yplotmax 100 xplotmin 0 yplotmin 0 nxgrids 10 nygrids 10
calc_treatment	calc_treatment	Firstlogging - forest managers decision loggingcycle - forest managers decision
treatment	RIL	pre-set by SYMFOR
logqualify	qualify1	dbhthreshold (see section 3.3) qualitylimit 0.3
logselect	select1	nlogmax 8.0 maxextract 500 minextract 0.0
felling	directional	cutdirection 135
planskidtrails	branched	accesspointx 50.0 accespointy 0.0 joinangle 60.0
calcskidcorners	sharpcorners	pre-set by SYMFOR
dragdamage	dragdamage1	pre-set by SYMFOR
skidprepdamage	skidprepdamage1	skidprepradius 3.0
skidtrails	skidtrails1	skidwidth 4.0
skidtraildamage	skidtraildamage1	maxdbhdamage 30.0 damageprob 1.0
calc_ages	calc_ages2	skidpersist 40 logpersist 40

Table 6: Suggested settings for RIL (the shaded areas highlight where RIL differs from conventional)

- **The primary characteristics of RIL are the preplanning of skid trails and directional felling.** Skid trails are pre-planned in order to reduce the total area damaged, and directional felling contributes to this reduction in area damaged. In SYMFOR branched skidtrails create a smaller area of damage per m³ extracted than straight ones, and directional felling reduces the amount of skidprepdamage and dragdamage.

- **There is also a limit to the number of stems which can be felled per ha.** Within the Swappable function ‘logselect’ the ‘nlogmax’ parameter is set to 8 to reflect this. As with conventional logging (above), the additional damage caused to the residual stand during harvesting can be decreased by altering the parameter values within the modules dragdamage1, skidprepdamage1, skidtrails1 and skidtraildamage1.

5.3 Saving a group of modules or parameters as a set

Once you have chosen a set of modules and/or parameters to represent your particular silvicultural treatment, you may wish to save them for use in the future. Saving a set of modules/parameters avoids the need to have to remake them, and is useful if you want to repeat a treatment on a different stand of forest. It is also necessary, when setting up a multiple run, to load a pre-made set of ‘Module Choices’ and ‘Parameters’ (see section 6).

To save any group of modules or parameters simply click on the ‘save set as...’ button in the window you have chosen them in. You will then be prompted to name the set – it is suggested you choose a name which describes the set in some way

for example RIL50 – reduced impact logging with a diameter limit of 50cm
RIL60 – identical reduced impact logging, but with a diameter limit of 60cm

6. Single Runs

6.1 Introduction

It is possible to perform any SYMFOR run once before looking the results, or to repeat the same run several times and undertake some statistical analysis upon the results. **For detailed analysis it is essential to use the multiple run option** (which is covered in the next section). However for new users and those who want to get a feel for how the model works under different settings, it is best to start with a single run.

The single run option also has the advantage that the user can view a number of graphical displays which show how the stand structure is changing, as the run proceeds. This section therefore concentrates upon these displays and how to view them – outputting and analysing data from a single run is generally not worthwhile (see section 7), although this can be done by following steps 1-6 in Section 7.

6.2 Starting a single run

To start a single run go to the Model Manager page and select the drop down menu ‘Start run’ then ‘new single run’.

Select ‘tree data’ and ‘stand data’ input files as directed in section 7.2. You will then arrive at the window below

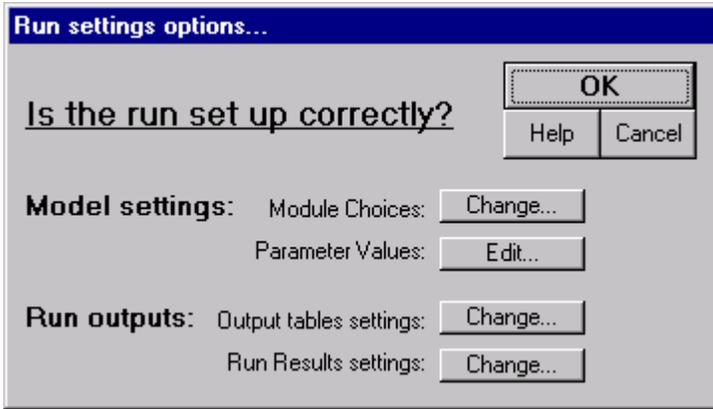


Figure 2: Single Run - Model settings and Run outputs window

This window allows the user to set the run to his exact specifications, and to dictate how the output data will be produced and to where it will go.

Model Settings: here you can choose the modules which you want to use for the run and set the parameters - it is advisable to set the module choices first, before going on to edit the parameter values. New users may wish to set the modules according to Table 5 or 6. The parameter values can then be edited, again according to Tables 5 and 6 if desired.

Run Outputs: basically this section of the window allows the user to specify what data to output, when to output it, and into what table it should go.

As stated above it is generally not worth outputting from a single run. The model can be run and the displays viewed even if the Run Outputs have not been set. To set the run outputs however, follow the procedure outlined in section 7.2, part 5 (Data Output File).

Once the previous window has been completed, click on OK and the following window will be displayed.

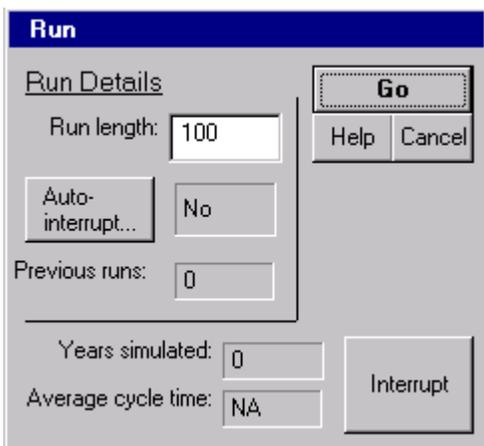


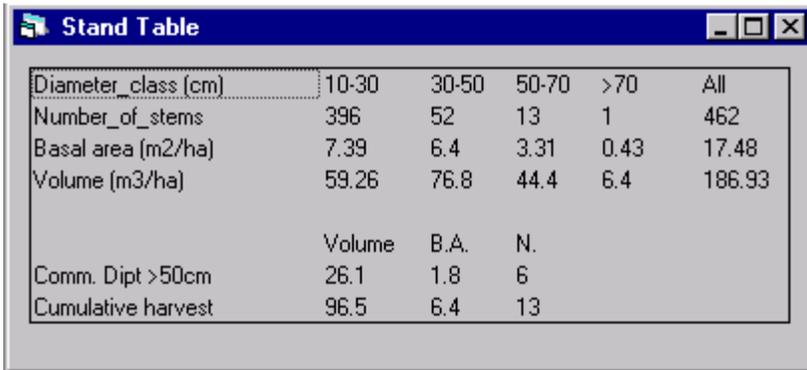
Figure 3: the single run control window

In this window set the length of run you want, and click on 'Go' to start the run.

The ‘Interrupt’ button can be used at any time to temporarily halt the run – this is useful if you want to examine one or more of the displays at a particular point in time, before allowing the run to continue.

The following displays can be accessed from the ‘Displays’ drop down list in the Model Manager window.

6.3 The Stand Table



Diameter_class (cm)	10-30	30-50	50-70	>70	All
Number_of_stems	396	52	13	1	462
Basal area (m2/ha)	7.39	6.4	3.31	0.43	17.48
Volume (m3/ha)	59.26	76.8	44.4	6.4	186.93
	Volume	B.A.	N.		
Comm. Dipt >50cm	26.1	1.8	6		
Cumulative harvest	96.5	6.4	13		

Figure 4: The Stand Table display

The Stand Table shows a summary of the structure of the forest as the run proceeds (note it is updated every 10 years). The upper section shows data for all the trees in the stand, whilst the lower section is concerned with commercial species only. This display shows the stand to contain 6 Commercial Dipterocarp stems above 50cm dbh with a timber potential of 26.1 m³ (at this point in time). Thirteen stems were removed during the first harvest, giving a yield of 96.5 m³.

6.4 The Plan View

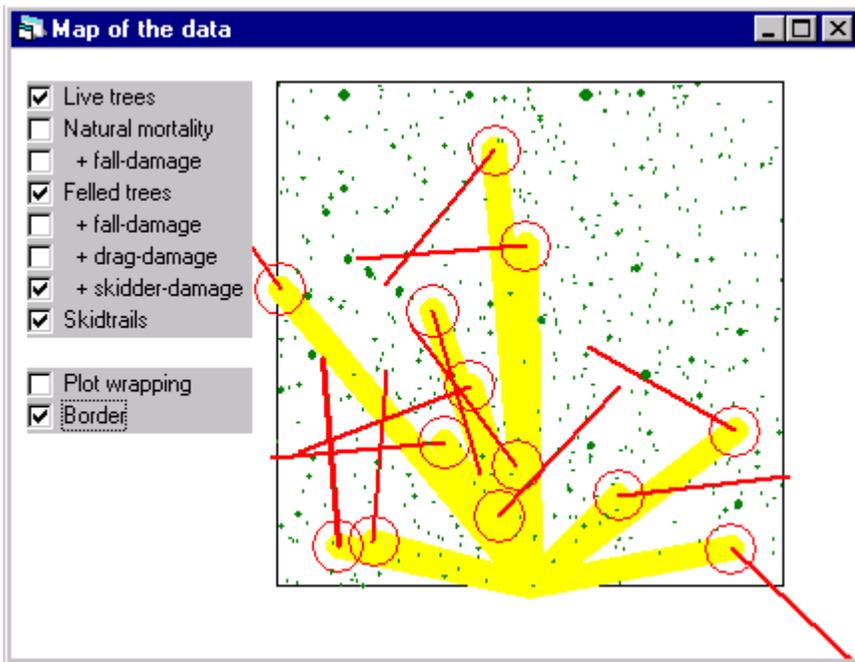


Figure 5: The Plan View display

The plan view shows a map of the location of every tree in the stand – the size of each dot is proportional to the dbh of the tree. The options on the left hand side of the window allow the user to select exactly what is, and what is not, shown on the map.

In the example above the thin straight lines represent felled trees, and these have been felled in a random direction (in relation to the skid trails) as the module for ‘undirectional’ felling was selected. The thick shaded lines are the skid trails, with all boles being skidded straight to a common point at the edge of the plot, because the ‘straight’ skid trails module was selected.

Finally, the circles represent the area of damage around the felled trees stump, caused by the bulldozer as it manoeuvres the bole into a position suitable for skidding. The size of this circle of damage is set by the ‘skidprepdamage’ swappable function.

6.5 Time series plot of Run Results

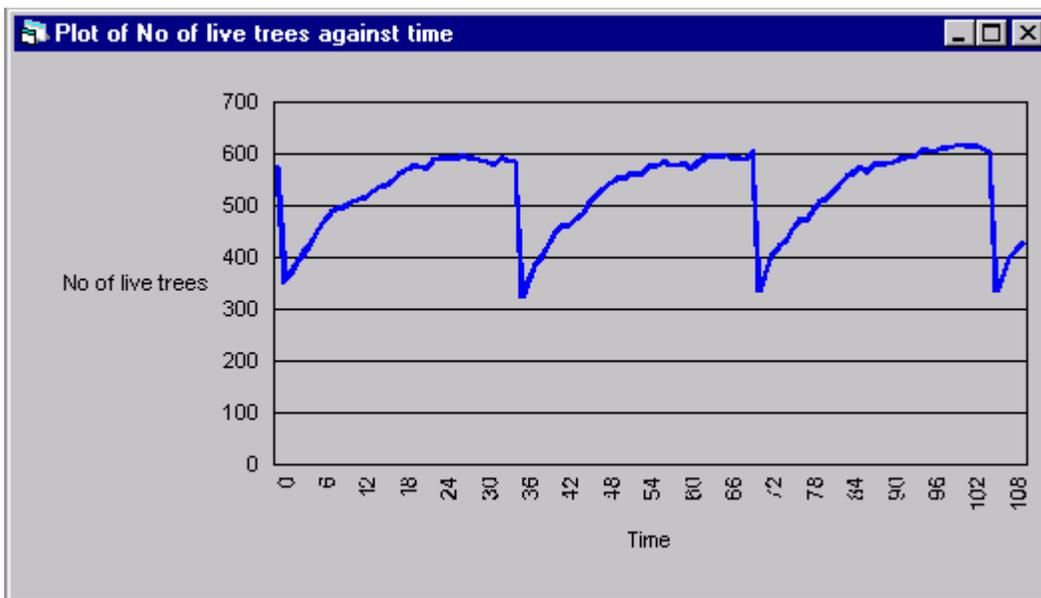


Figure 6: The ‘Time Series plot of run results’ window. In this example it has been set to display the number of live trees against time.

The time series window presents a graphical representation of one aspect of the status of the stand as the run proceeds. The window above shows how the number of live trees in the stand varies over 3 felling cycles. Note that in this case all ‘livetrees’ are counted, there is no disaggregation of species group, utility group or size.

To view a different aspect of the stand status, double click with the right mouse button anywhere on the display, and the ‘Plotting Options Editor’ window will appear. From the drop down list in the Time Series variable box, the user can select an alternative variable to be displayed.

Only three of SYMFORs display options have been covered in this section. The displays not covered here can be accessed from the same window as those shown above. It is recommended that new users ‘explore’ this area of the model in order to observe the full range of data which SYMFOR can produce. Knowledge of this will assist in selecting the correct output data for a multiple run, and with subsequent analysis.

7. Multiple Runs

7.1 Why are multiple runs necessary? The random element.

Many natural processes in the forest occur in an apparently random manner. An example is natural mortality and treefall – it is impossible to predict exactly when a tree will die, when (or if) it will fall over and in what direction. SYMFOR deals with this by increasing the probability of death with increases in dbh, and causing a certain proportion of all dead trees to fall over. Those trees that do fall over do so in a random direction.

This random (or stochastic) element of SYMFOR is generated by the 'random number seed' seen at the bottom of many windows. It is important because it means that no two runs produce the same result - even when the same forest stand is grown for the same length of time performing the same (or no) silvicultural treatments. Therefore, in order to get reliable results upon which management decisions can be made, it is necessary to run SYMFOR several times for any one treatment, and average the results.

Example: You want to find out the commercial timber yield from a stand of forest 35 years from now. Running the model once may give a yield of 53 m³. Running it a second time could give a yield of 45 m³ (because a large tree that was harvested in the first run fell over in year 34 of the second run, and was therefore not harvested). Neither of these results is accurate enough to base any decisions upon. It is therefore necessary to perform 10 (or more) identical runs and take an average of the timber yield over all 10. This will give a much more reliable result. (Even a small inaccuracy of 0.5 m³ ha has massive implications when scaling up from one ha to a concession level).

Alternatively, you may wish to repeat the above, but look at the yield given by several different 1ha stands within a concession.

Ideally, it would be best to draw results from several different plots with each one being grown by SYMFOR several times.

7.2 How to perform a multiple run.

To start a multiple run go to the Model Manager page and select the drop down menu 'Start run' then 'multiple run' – this will bring up the 'Multiple Run Manager' window. From here click on 'Create New Instruction', and the following window will appear.

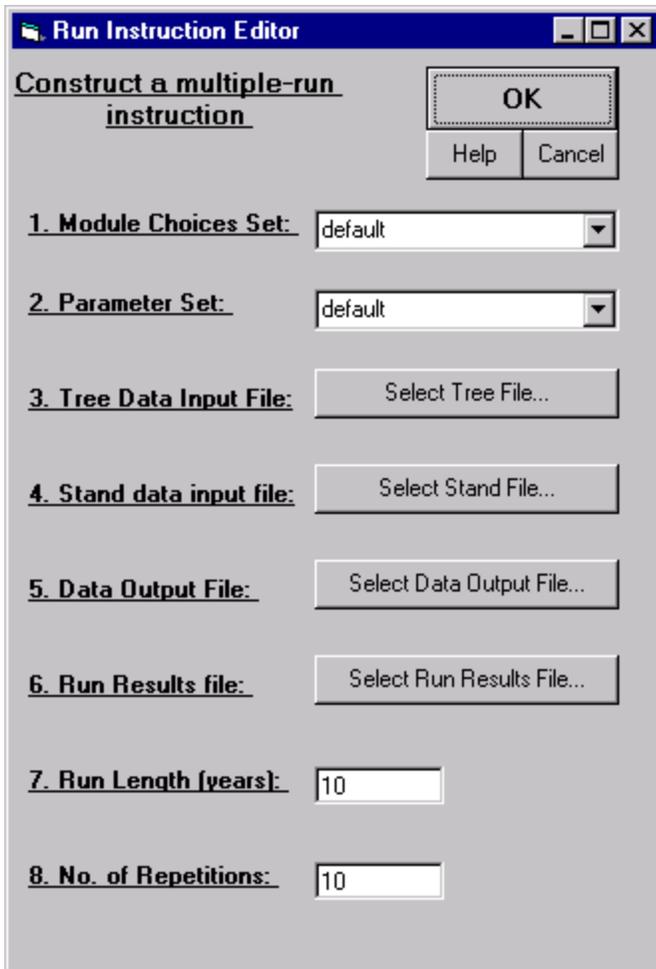


Figure 7 : The SYMFOR Multiple Run Instruction Window

There are 8 sections to this window. What each section refers to and what lies within it is covered below.

1. Module Choices Set

The modules available to a user in setting up a SYMFOR run are explained in Section 3 of this document. The procedure for choosing them and saving them as a set is explained in Section 5.3. This section of the multiple run instruction window requires a pre-made set to be chosen from the drop down list.

2. Parameter Set

The parameters associated with any module, and how to save them as a set, are documented in Sections 4 and 5.3 above. This section of the multiple run instruction window requires a pre-made set to be chosen from the drop down list.

3. Tree Data Input File

On clicking the button marked 'select tree file' the following window will appear-

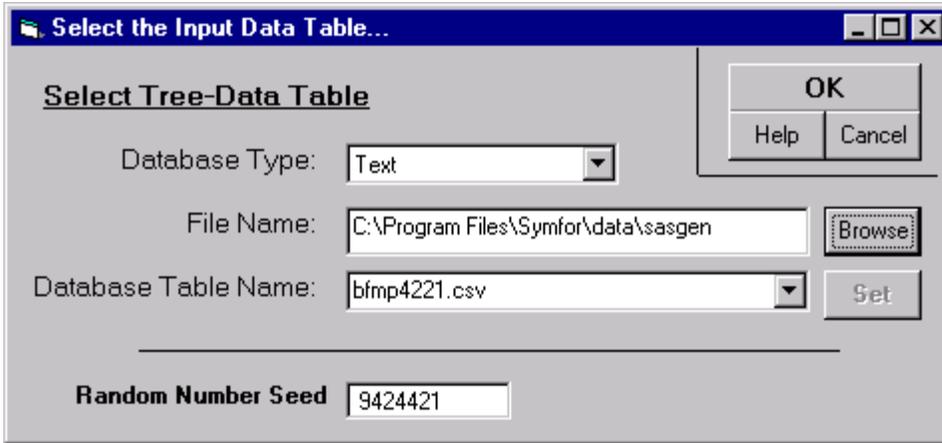


Figure 8: Selecting and inputting the Tree Data Table

This prompts you for information on the format, location and name of the ‘Tree Input Data Table’ to be used. Once the database table has been found, and its name appears at the end of the text in the ‘File Name’ box, click on set – this brings the database table name into the relevant window. Then click OK.

SYMFOR requires the following information about every individual tree (>10cm dbh) in the stand:

<i>Column 1</i>	<i>Column 2</i>	<i>Column 3</i>	<i>Column 4</i>	<i>Column 5</i>	<i>Column 6</i>
treenumber	xposn	yposn	speciesgrp	utilgrp	dbh

This must be arranged in the above format. Various standard database types can be used to create this table, although ‘Text’ is recommended as it is the most flexible.

For clarity:

- the **tree data** table contains the above information for each individual tree in a stand
- the **stand data** table contains information on the history of the stand as a whole

4. Stand Data Input File

On clicking the button marked ‘select stand file’ a similar window to that above will appear. SYMFOR needs certain information about the history of the stand you are using the model to grow – this is best provided using the ‘Stand Wizard’.

Stand Wizard: Detailed data analysis has shown that the rate and pattern of growth is different in logged-over and undisturbed forests – trees in logged over forests grow slightly faster than equivalent trees in an undisturbed area. SYMFOR needs to know if the forest stand you are about to ‘grow’ (your input data) has been logged previously or if it is a virgin stand.

Using the Stand Wizard is the easiest way to provide SYMFOR with this information. If the stand has not been logged, select ‘no’ then press ‘Finish’. If it has been logged previously select ‘yes’, and answer the following questions

- In what year was the stand logged?
- In what year was the tree data collected?
- How many trees were left in the stand after logging?

5. Data Output File

On clicking the button marked ‘select data output file’ (Figure 3) a window headed ‘Edit the data Output Settings’ will appear. Here click on ‘New Output Table’, and the following window will be brought up –

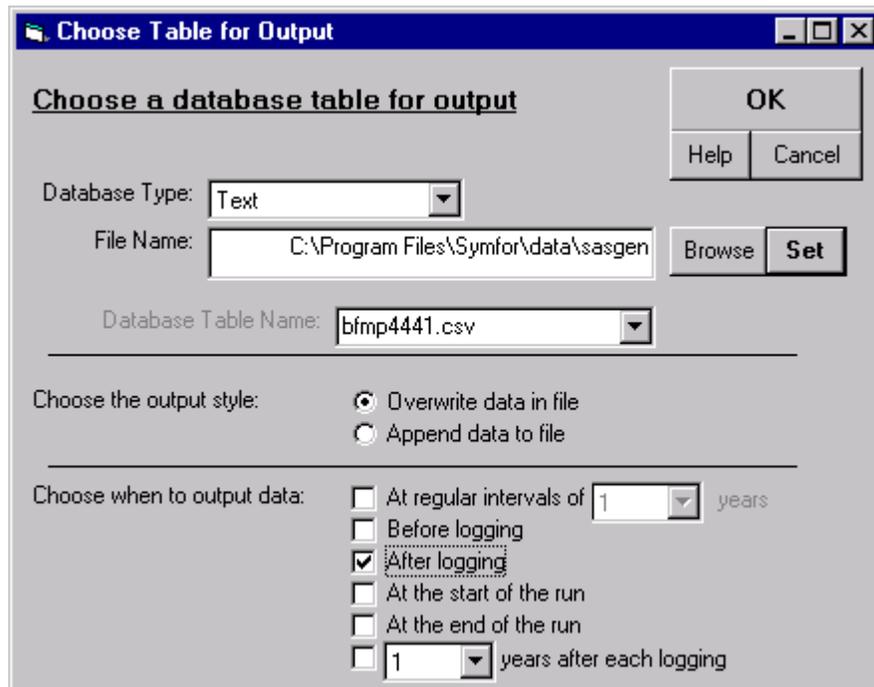


Figure 9: Choosing a table for the output data, and at what points in the run that data is to be output.

First fill in the details in the top section of the page – these let SYMFOR know the location, name and format of the table into which the output data is to go.

Choose the output style: unless you want to add data to a table which already exists, the output style should be ‘Overwrite data in file’.

Choose when to output data: when you should output data depends upon what aspect of a SYMFOR run you wish to look at. For example, if you wish to look at the volume of timber logged during a harvest then you should output ‘After logging’. If you wish to observe the growth of the forest over time then output ‘at regular intervals of _ years’. Each box is self explanatory and it is also possible to select more than one (each also represents an ‘output reason’, 1-6, see next section).

Once all the settings in this window have been selected click on OK and SYMFOR will take you to the following window -

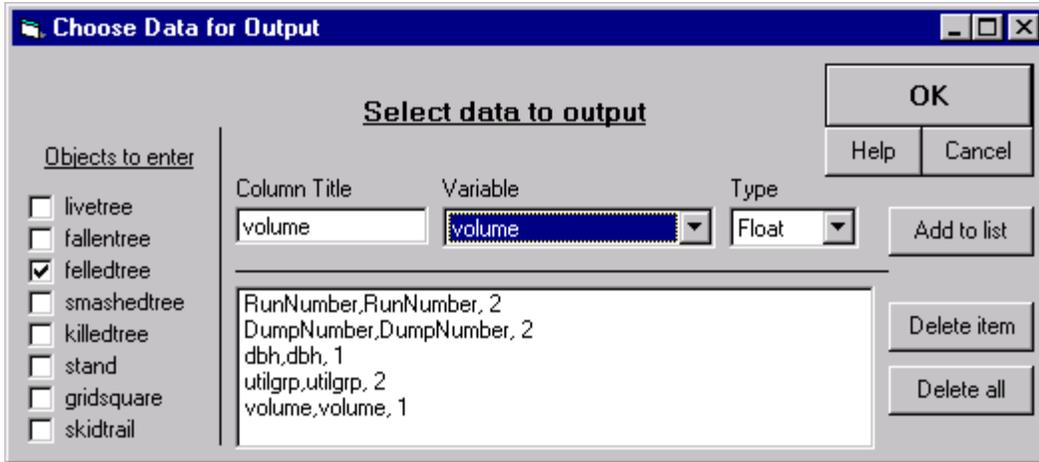


Figure 10: Selecting exactly what data you want SYMFOR to output

The previous window (Figure 5) asked you to specify where to output the data to, how to write it and at what point in the run to do this respectively. The ‘Select data to output’ window (figure 6) allows you to specify exactly what data you want. This can be broken down into two parts

- 1) *which ‘object’ do you want data on?* The choice of objects can be seen on the left hand side of the window. Put simply, this choice can mean deciding if you want information on each ‘livetree’ left growing in the stand, or each tree which has been felled – ‘felledtree’. Again, the object(s) you want data on will depend upon which aspect of the forest you want to look at. The SYMFOR objects are summarised below

Object	Explanation
livetree	any tree still standing and growing in the SYMFOR stand
fallentree	a tree which has died naturally and fallen over
felledtree	a tree which has met the logging criteria and has been felled
smashedtree	a tree which has been killed as a result of another tree falling over , or killed during the making of a skid trail
killedtree	a tree poisoned during a thinning operation (thinning is not yet operational)
stand	the stand as a whole (rather than data on each individual tree)
gridsquare	a 10x10m plot - there are 100 of these in a 1 ha stand
skidtrail	the total area in the plot covered by skidtrails

Table 7: objects for which data can be output

- 2) *What data do you want about that object:* the drop down list under ‘Variable’ presents all the categories of data which SYMFOR produces for each object. For example, if you output data on felledtrees, you may want to know (for each felled tree)
 - Outreason – the reason for output of this data. (The numbers 1-6 correspond with the categories of ‘choose when to output data’, in table 5)
 - Runnumber – the run that the tree was felled in
 - Dumpnumber – was the tree felled in the first logging of that run (dump1), or the second logging of that run (dump 2) etc
 - dbh – the diameter at breast height
 - utilgrp – the utilisation group that it belongs to
 - volume – the volume of the bole of the felled tree

The data variables which SYMFOR can output depends upon the object you are outputting for.

To select a category of data for output simply select it from the drop down list and click the button marked ‘add to list’. It is advisable to select ‘outreason’, ‘runnumber’ and ‘dumpnumber’ in all cases, as these form helpful markers for subsequent analysis of the data.

When you have finished selecting the output data you want, click on OK. The following window will appear –

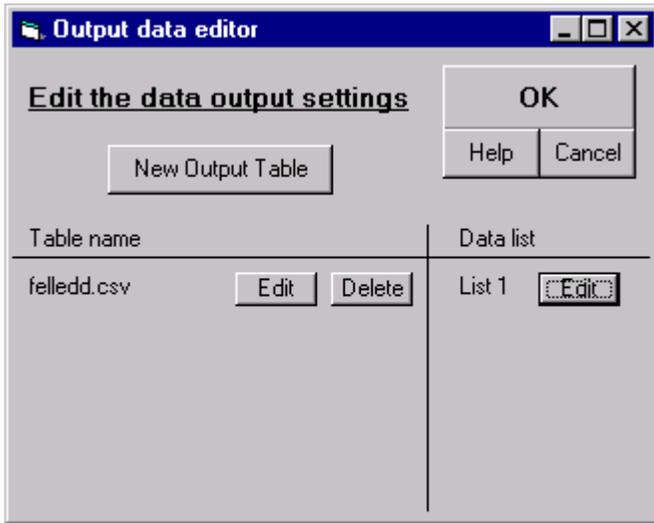


Figure11: editing the table into which your data is to go, and specifying what exactly that data is to be

This window allows you to do exactly as it says – from here you can edit the settings which you created in the previous two windows.

Editing the Table will take you back to the window in Figure 5.

Editing the Data list will take you back to the window in Figure 6.

When you are satisfied that everything is set correctly, click OK and you will be taken back to the window in Figure3.

6. Run Results File

This section of the window is concerned with the destination of data used to construct the visual displays. These are rarely used during a multiple run, and are not covered here.

This window can therefore be ignored.

7. Run Length (years)

This is as simple as it appears – how long do you want to grow your stand of forest for?

It is important to bear in mind the settings you have previously made; ie if you are logging every 35 years the run must be at least this long.

8. Number of Repetitions

A minimum of 10 is recommended in order to achieve reliable results, however more is preferable.

Your multiple SYMFOR run is now set up. Click OK and then ‘Go’ in the top right hand corner of the Multiple Run Manager window.

8. Treatment and Analysis of Output data.

The SYMFOR model essentially takes a list of numbers which describe a stand of forest (the tree input data), alters these numbers according to the Ecological Model and the Silvicultural settings, and outputs a modified list, or lists, of numbers in table format. As such, SYMFOR alone does not provide a 'result', but rather a set of data from which a result, or several results, can be drawn.

It is therefore essential to perform some sort of after run analysis on the output data. It is also necessary to know what sort of analysis you wish to perform / what type of results you wish to draw from the data before setting the run, in order that all the required output data is produced.

There are two types of tool which can be used to analyse the results of a SYMFOR run,

- the SYMFOR 99 Post Processor
- any statistical analysis software or database package (including SAS, SPSS, Minitab, Genstat or Microsoft Excel)

These are not covered here, as they are beyond the scope of this document and are fully explained in others.

For new users of SYMFOR the 'Post Processor' is recommended as it takes SYMFOR output data and performs a range of standard analyses upon it. This programme can be found on the SYMFOR 99 Installation CD or the Growth and Yield Modelling web site, at <http://meranti.ierm.ed.ac.uk/g&y/home.htm>

9. Some Illustrative Results

The following tables answer some of the ‘what if...’ scenarios in Section 2.1.

They aim to illustrate some of the forest management applications of SYMFOR, and to demonstrate the types of questions which can be addressed using SYMFOR. The aim of this section is not to present definitive results, and the figures should therefore be regarded as illustrative/indicative only.

9.1 The effect upon yield of increasing the felling limit

		Realised yield on logging (m ³)	Potential yield (m ³) (if logged under same utilgroup, dbh and quality criteria)				
		Year					
		0	30	35	40	45	50
Harvesting Style	TPTI > 50	128.2	17.1	20.8	23.5	28.0	30.8
	TPTI > 60	111.8	28.0	30.6	32.9	35.6	35.8

Table 8: Commercial timber harvest under TPTI with minimum logging dbh of 50 and 60 cm. Figures shown represent the average over 10 replicate SYMFOR runs. The model is as defined by the TPTI settings in Table 5.

The SYMFOR run which was used to produce the figures in Table 8, above, used tree data from BFMP RKL IV, plot 12, recording unit 3, campaign 1 as its input. This was a plot with a low number of trees compared to the average for all RKL IV plots, but a high commercial volume (three trees held a commercial volume of 75 m³). The figures shown above therefore are not typical, but demonstrate how the state of the initial stand can influence results.

The table shows the TPTI >50 harvesting style to yield 17 m³ more in the initial harvest than the TPTI >60 treatment. This means that 17 m³ of timber is left in the forest under the TPTI >60 treatment, and explains the higher potential yield of this treatment at every point in the future, despite the higher minimum dbh.

It can also be seen that as time passes, the potential future yields from the two treatments become more similar. The difference in yield if the second logging was in year 30 is 11 m³, if it is in year 50 the difference is only 5 m³. This is probably as a result of natural mortality amongst the older / larger trees which were between 50 – 60 cm dbh at the year 0 harvest, and were therefore not removed under the TPTI >60 treatment. SYMFOR could be used to verify this by outputting data on all ‘fallentrees’ during the years 30 – 50 after the initial harvesting.

A further informative analysis would be to look at what yield the TPTI >60 treatment would give in future years, if the minimum felling dbh was revised to >50 in those years.

9.2 Comparison of Yield; TPTI and RIL

		Realised yield on logging (m ³)	Potential yield (m ³) (if logged under same utilgroup, dbh and quality criteria)				
			Year				
		0	30	35	40	45	50
Harvesting Style	TPTI >50	78.8	11.3	14.8	16.9	18.0	22.6
	RIL >50	71.6	33.1	34.2	38.9	38.9	42.5

Table 9: Commercial timber harvest under TPTI (conventional) and RIL harvesting. Figures shown represent the average over 10 replicate SYMFOR runs. The model is as defined by the TPTI and RIL settings in Tables 5 and 6.

In table 9.2 above, the difference in the year 0 yield arises from the ‘8 trees per ha’ felling limit within RIL. With TPTI there is no upper limit on the number of trees to be felled per ha.

The data demonstrates two elements relating to the harvesting and yield

- **The differences in yield between TPTI and RIL.** In the initial (year 0) harvest TPTI yields 7 m³ more than RIL. The potential RIL yield in any of the future years is approximately 20m³ greater than the potential TPTI yield. Part of this additional volume (7 m³) can be explained as the timber not removed by the RIL logging in year 0. The remainder (13 m³) can be attributed to the lower disturbance caused by the RIL operation.
- **The effect of felling cycle length on yield.** For both treatments the potential future yield increases with the length of the felling cycle.

As stated above, these figures are intended to illustrate the uses to which SYMFOR can be put, rather than to be definitive. However they do highlight areas which could be further illuminated by using SYMFOR with a greater range of input data and more repetitions. One example would be to address the questions

in which 5 year period does the potential yield increase the most?
and therefore, what is the ideal felling cycle length in terms of maximising annual increment?

9.3 Comparison of Yield with equal initial yield, TPTI and RIL

		Realised yield on logging (m ³)	Potential yield (m ³) (if logged under same utilgroup, dbh and quality criteria)				
			Year				
		0	30	35	40	45	50
Harvesting Style	TPTI >50	52.9	88.5	90.5	89.5	88.3	92.5
	RIL >50	53.9	54.8	49.6	52.7	54.5	59.6

Table 10: Commercial timber harvest under TPTI (conventional) and RIL harvesting. SYMFOR was set to extract the same volume for both treatments in year 0. Figures shown represent the average over 10 replicate SYMFOR runs. The model is as defined by the TPTI and RIL settings in Tables 5 and 6.

Table 10 shows the potential future timber yield under the same two treatments, but with the volume extracted in year 0 equal for TPTI and RIL. (SYMFOR will continue felling trees until a set extraction level is reached. However, because SYMFOR cannot extract half a tree, the set extraction level is often surpassed slightly. This explains the 1 m³ difference in the year 0 yield.)

The potential yield in every year is greater for TPTI than RIL – this is probably due to the 8 stems per ha felling limit in RIL. Again this initial analysis has highlighted an area which requires more detailed research.

This scenario is potentially of more use to forest managers than that in table 9, as it allows the same income to be raised from log sales in the first cycle.

9.4 TPTI and RIL Yields over 210 years

		Realised yield on logging (m ³)	Yield in future cycles (m ³) (if logged under same utilgroup, dbh and quality criteria)					
			Year					
		0	35	70	105	140	175	210
Harvesting Style	TPTI >50	88.3	12.8	35.0	34.4	33.8	31.8	38.3
	RIL >50	66.9	36.0	31.1	34.8	41.7	38.1	35.0

Table 11: Commercial timber harvest under TPTI and RIL over six cycles of 35 years. Figures shown represent the average over 10 replicate SYMFOR runs. The model is as defined by the TPTI and RIL settings in Tables 5 and 6.

The above table shows the expected yields from TPTI and RIL over six 35 year cycles. The RIL yield is greater in all years except 0, 70 and 210 – this is probably due to the 8 stems per ha extraction limit leaving a greater number of large trees standing in the forest, to be harvested in the next cycle. Further SYMFOR runs and subsequent analysis could verify this.

10. Conclusions

By this point the reader should be equipped with a knowledge of how SYMFOR works and the range of questions which it can potentially be used to answer. This document has covered the following points

- the importance of growth and yield modelling in formulating practices and plans for SFM
- the range of silvicultural activities which it is desirable to model within SYMFOR
- the structure of SYMFOR – swappable functions, modules and parameters
- how to represent TPTI (conventional) and RIL logging within the model
- performing single runs and viewing displays
- the need for multiple runs, and how to set up and output data from a multiple run
- the need for analysis of data outputs, and with what software this can be done
- presentation of some illustrative results in order to demonstrate some of the types of questions which SYMFOR can be used to answer

It is evident that SYMFOR can be used to provide data which can be used to make short, medium and long term predictions relating to several aspects of the growth of a stand of forest. These include; the potential commercial timber yield; the species composition and structure of the stand; the rate of recruitment of young trees; the type of damage sustained and area affected as a result of different styles of harvesting.

These factors can also be examined under a range of different conditions, such as; a set felling intensity per ha; a lengthened or shortened felling cycle; or no silvicultural interventions at all.

SYMFOR is therefore of use to forest managers wishing to observe what the outcome of any particular forest management practice is likely to be – in terms of initial timber yield, damage to the stand and future yield. Thus it is a tool which can assist with the planning of a system for sustainable timber production from sustainable forestry. It is also of use to those wishing to monitor changes in the ecological (species) structure of the forest as a result of various silvicultural interventions, or none at all.

This document has also covered the essential pre-requisites for effective use of SYMFOR, these are

- permanent sample plot data containing 6 key data elements for SYMFOR input
- a basic knowledge of silvicultural practices and processes
- an understanding of simple statistics and data analysis

It should now be clear that SYMFOR is a complex and potentially powerful tool which can be used to provide data from which a wide range of predictions relevant to sustainable forest management can be made. This document has aimed to introduce SYMFOR to those who have never used it before, to demonstrate the processes involved, and to give the reader sufficient knowledge to allow him to formulate and inform his own forest management questions using SYMFOR.

11. References

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