

**FOREST SERVICE SIMULATOR
(FSSIM) ©**

USERS MANUAL



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**Beta Release
February 1997**

The FSSIM software was developed by the B.C. Ministry of Forests, Timber Supply Branch. Documentation was prepared by Timberline Forest Inventory Consultants Ltd., with funding provided by Forest Renewal BC.

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USING THIS MANUAL

This manual has been designed to assist the user in building data inputs and performing simulations with the Forest Service Simulator (FSSIM). It is arranged in seven sections plus appendices which are designed to quickly move the user to a basic level of competence and at the same time make access to detailed information quick and intuitive. Although this manual and its electronic version have been designed to conveniently provide access to any required information, the sections are presented in a logical order to help the new user build an understanding of the process.

The manual sections are:

1. Program installation - Information on program distribution, installation and system requirements.
2. Conceptual description - Including a brief background on forest modelling in BC, this section is a conceptual description of the FSSIM approach to simulating forest development.
3. Program functionality and flow - A detailed description of program execution and flow to facilitate problem solving.
4. Running the program.
5. Sample data set and simple analysis scenarios.
6. "How to" Help pages - Simple instructions to handle common modelling situations.
7. Glossary - Designed to inform and aid access to the user manual.

Appendix I - Input File Structure - Detailed descriptions of input file structure including documentation of required and optional items.

Appendix II - Output File Structure - Detailed descriptions of output file structure.

This manual is being distributed with the beta version software. Any comments or suggestions to improve this users manual are welcome.



1.0 PROGRAM INSTALLATION

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1.0 PROGRAM INSTALLATION

FSSIM has been compiled in two operating environments:

- UNIX (Solaris Versions 2.3 and 2.5); and
- Windows (Windows®95 and WindowsNT™).

1.1 UNIX

The UNIX version consists of a single executable file which can be downloaded from the Ministry of Forests FTP site. This file should be placed in your working directory, and included in the path statement (Solaris users include path in the .cshrc file).

1.2 Windows

The Windows application is provided on a floppy diskette. The diskette contains a README file, along with an installation batch file. To install the directories:

1. Load the diskette into the floppy drive (usually a: or b:)
2. Type a:\INSTALL (or b:\INSTALL)

This will create an FSSIM directory on your C drive. A DATA subdirectory is also created, and several sample data sets are provided.

The INSTALL routine will not create a Program Group. The program can be run from the Windows NT File Manager, or the Windows 95 Explorer. Alternatively, the user can create a Program Group.

Note: The amount of RAM required on either the UNIX or Windows platforms depends largely on the size of the data sets to be analyzed. 32-64 megabytes is recommended.



2.0 CONCEPTUAL DESCRIPTION

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2.0 CONCEPTUAL DESCRIPTION

Section 2 is designed to give the user an appreciation of FSSIM in terms of its origins, philosophy and range of utility. Section 2.1 provides a background to development of FSSIM. The sections which follow outline the concepts behind the model's structure and functional flow.

2.1 Background

In 1992 the Ministry of Forests (MoF) began a major review of timber supply across the province. There was an identified need to update the information available to, and the analytical techniques used in, the Allowable Annual Cut (AAC) determination process. It had become clear that existing procedures no longer reflected current management practices including the protection of non-timber values. Fundamental to the review process was the development of a long range forest development model that could address integrated resource management issues.

FSSIM was designed to develop long range forest development and timber supply projections in the context of the forest planning environment in BC, specifically to more reliably address integrated resource management (IRM). In an IRM context, a variety of constraints and objectives over and above timber requirements are recognized. Management for these other resources and products can be related to restrictions on the removal of forest cover and the distribution of those removals through the use of forest cover constraints. FSSIM was developed within the MoF specifically to address such forest structure control requirements.

Continuous evolution of the original model has resulted in the currently released version of FSSIM. It is designed to accommodate multi-layer forest cover requirements. It is capable of simultaneous use of overlapping constraints to model both traditional cover requirements and, for example, biodiversity requirements at watershed or landscape levels.

Future modifications will accommodate a number of alternative silviculture strategies, including commercial thinning and partial cutting.



2.2 Application

FSSIM is a simulation tool. Key processes of forest development and management intervention are defined in simplified, intuitively understandable terms, and organized to occur repeatedly in a specified order. By simulating the interaction between these processes, the model provides a means to project the impact of a specified management strategy on selected aspects of forest structure.

Using this tool in an iterative fashion, systematically testing alternative sets of management options, the analyst can provide resource managers with considerable insight into the consequences of alternative strategies on timber supply.

2.3 Design Principles

FSSIM is a sequential inventory projection model. "Inventory projection" refers to the growth of the inventory using age-dependent yield estimates. "Sequential" refers to the ordering of forest development processes (natural and management-induced) inherent in the model design and/or based on harvest rules, priorities, and constraints imposed by the analyst. This order is designed to reflect, in very simplified terms, the order in which these processes occur in the real world. It should be recognized however, that in reality all of the simulated processes overlap in time, and many more occur in reality but are not captured in the simulation process.

Beyond defining the sequence in which events are assumed to occur, the model has no built-in functional relationships such as stand growth forecasts or harvest regeneration responses. Rather, the model provides a framework into which the user can incorporate information which pertains to the specific analysis problem. FSSIM acts as a book keeping tool, keeping track of the sequence of events and providing reports on the expected outcome.

The underlying structure of FSSIM is built around the relationships between 3 components of the forest, namely:

- Classes
- Analysis Units (AU) and associated yield tables
- Zones



Conceptual Description

These components are described in Sections 2.4 - 2.6. In general, they are used to characterize the forest inventory with respect to structure, yield, and management focus. A fourth component, the Group (Section 2.7) is used in a more flexible fashion to aggregate these components for different purposes. The relationships between all four components are described in Figure 2.1. Zones are composed of analysis units which have constituent forests classes. Classes, however, can belong to more than one group depending on data model design.

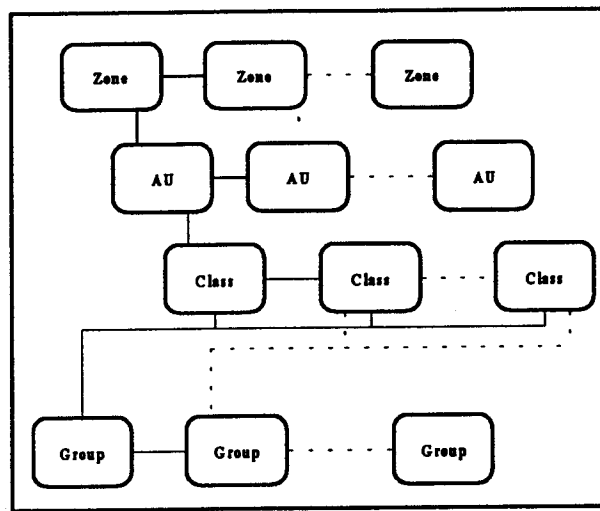


Figure 2.1 - FSSIM forest components

The user must specify four basic sets of inputs:

1. The inventory of the forest at the beginning of the simulation;
2. Estimates of how individual stands or aggregates of stand types will grow;
3. The rules which define how management intervention is controlled; and
4. Parameters which control the simulation process itself.



All of these inputs are defined in a set of blank delimited ASCII files. The purpose of each file is described in Section 3.1. Input file formats are detailed in Appendix I.

Figure 2.2 is a generalized representation of program flow. Each simulation run consists of data input and iterative processing of the following steps:

- The creation of a harvest candidate list;
- Harvest;
- Reassignment of harvested stands according to the regeneration rules;
- Reduction for roading;
- Growing the forest to the beginning of the next simulation period, and
- A decision to continue simulation.

This is only a general overview of program flow. More detail can be found in Section 3.0 of this manual, as well as in the FSSIM Programmers Manual.



Conceptual Description

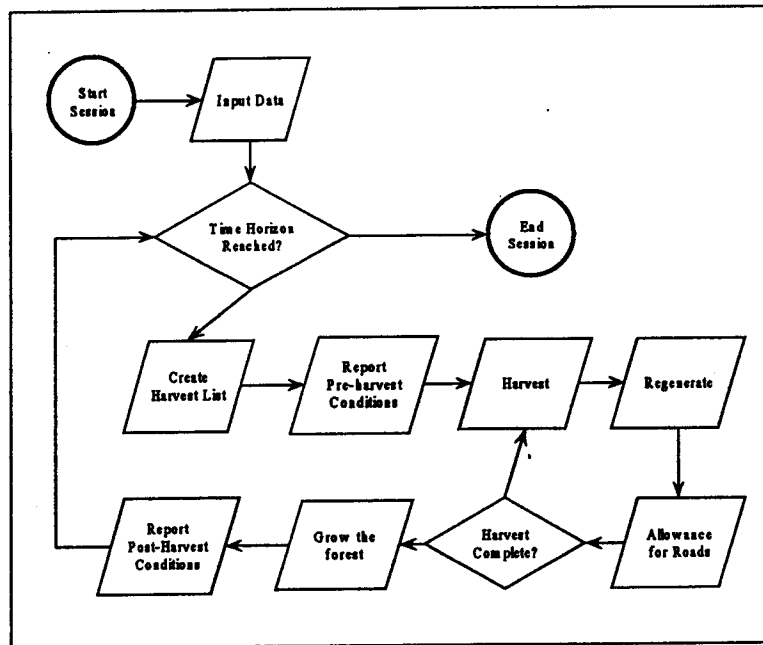


Figure 2.2 – Generalized FSSIM Program Flow

2.4 Stand Development

In order to reduce the complexity of the forest description for the purposes of timber supply simulation, one may choose to aggregate forest stands. However, it is critical that this aggregation not obscure differences in stand growth patterns or biological differences in forest stand productivity. Management differences are recognised by aggregating stands into *Zones* on the basis of similarity of management objectives, and spatial proximity (see Section 2.6). Biological similarity in terms of stand growth is captured by grouping stands into *Analysis Units* on the basis of similar species and site productivity. The need to simplify the problem through aggregation must be balanced against the need to create aggregations fine enough to capture significant biological variation.

Each analysis unit has associated with it a yield table, harvest candidacy requirements and regeneration characteristics shared by all forest classes assigned to that unit.



2.5 Forest Inventory

This is the state of the forest at the beginning of simulation, described in terms of *Forest Classes*. A forest class has a number of attributes assigned to it, and may be a discreet stand or more often an aggregation of stands having the same characteristics. These attributes include the management zone and analysis unit to which the class belongs, the class width (minimum and maximum age), area, and its characteristics with regard to contribution to harvesting or other goals.

Note: At the start of the simulation, the area in each class is evenly divided into 1-year classes.

2.6 Zonation

For analysis purposes the land base is segregated into *Zones* in order to model management criteria. These zones are usually defined on the basis of management objectives such as wildlife habitat, riparian zone protection or the protection of visual quality. Forest classes are aggregated into zones based on having the same management regime(s). These zones are normally defined as mutually exclusive, contiguous areas.

2.7 Grouping

FSSIM also permits the definition of *Groups* to facilitate the simulation of different, and sometimes overlapping management controls. Any combination of zones, analysis units and/or ages can be organized into groups based on this control requirement. Control could entail specification of harvest levels, or the establishment of forest cover constraints designed to create or maintain a target forest structure as defined by the management regime.

2.8 Forest Cover Constraints

Forest cover constraints (FCC) place restrictions on the distribution of age classes. They place maximum or minimum limits on the amount of area in young and old age



Conceptual Description

classes respectively found in specified components of the forest. These components can be defined as either zones or groups.

FSSIM models two constraint conditions:

1. Disturbance (below green-up)

The total disturbed area is to be maintained below a specified maximum green-up percent. The amount of area classified as disturbed cannot exceed this maximum. The disturbance category contains the area in classes that are younger than a specified maximum green-up age. The effect of a disturbance class constraint is to ensure that at no time will harvesting increase the area in classes younger than the maximum age above the maximum permitted.

2. Retention (old-growth)

The total retention area is to be maintained above a specified minimum old-growth percent. This category contains the area in classes that are equal to or older than the specified minimum old-growth age. The effect of this constraint is to ensure that at no time will harvesting decrease the area in classes equal to or older than the minimum age below the minimum permitted.

A disturbance constraint which is in violation at the beginning of the simulation will prevent harvest until such time as forest growth ameliorates the problem. Simulation of harvesting will not be allowed to violate a constraint.

A retention constraint in violation at the outset may not preclude harvesting. The model will reserve the oldest harvest candidates for movement into the retention class. As long as there is unretained area and/or volume above minimum harvest age harvesting may still occur.

Figure 2.3 demonstrates application of forest cover constraints in terms of class age.



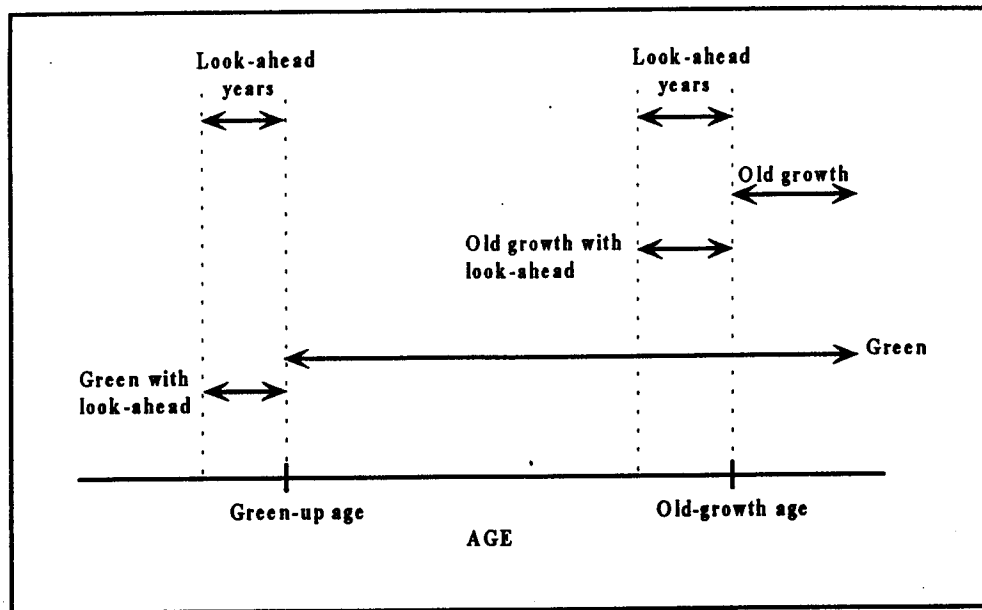


Figure 2.3 - Forest cover constraint concepts

Multiple and overlapping disturbance and retention constraints may be applied at the zone or group levels.

2.9 Harvest and Regeneration

Prior to harvest modelling, rules need to be established to define the order in which components of the forest (classes) are prioritized for harvest. Many rules and priorities come into play in building the harvest candidate list:

- A forest class's contribution status must be considered (contribution status is discussed in Section 3.1.4);
- Forest cover constraints must be met;
- Minimum harvest ages must be considered; and
- Harvest rules must be employed to order candidates.



Conceptual Description

Harvest rules available to the analyst are:

- Absolute oldest first. Classes are harvested in descending order of age;
- Relative oldest first. For each class, the difference between current age and minimum harvest age is first calculated. Classes are then harvested in descending order of this value;
- Absolute youngest first. Classes are harvested in ascending order of age; and
- Randomized. Classes are harvested in random order.

Harvesting involves:

- Capturing the volume associated with the forest class at its harvest age according to its analysis unit (yield curve) characteristics;
- Resetting the age taking into consideration any regeneration delay; and
- Reassigning the harvested area to one or more new analysis units.

Analysis unit reassignment, following harvesting, effectively defines the expected regeneration response of harvested forest classes.

Note: Regeneration delays should not be incorporated into regenerating yield curves. Such delays are specified separately in the FSSIM data model.

Harvest targets can be controlled by area or volume and set for the forest as a whole, or by group, or zone.

2.10 Allowance for Roads

Road development for accessing timber has an impact on the land base available for harvest and must therefore be considered in modelling. Existing roads are normally identified in the land base inventory and removed during the land base net down process. Future roads are accounted for by a reduction in previously unroaded areas after they have been harvested by FSSIM. The user defines a maximum age for which classes are assumed to be roaded and no future road reduction is made. In addition, a reduction factor is defined which is applied to the area of all classes older than this age



after they have been harvested. Because road reductions are made after harvest, they do not affect available volume or access constraint calculations during the period.

2.11 Projection and Growth

FSSIM simulates growth by incrementing the age of all forest classes by the period length at the ~~beginning~~^{end} of the period and ~~before~~^{after} any other activity.

2.12 Transfers

Transfers are used to reassign forest class attributes, including zone, analysis unit, age and class type. Transfers are useful in accounting for the inclusion/exclusion of specific forest components in a dynamic fashion. As an example, Timber Licence area within a Timber Supply Area (TSA) typically reverts to the TSA following harvest. The transfer mechanism provides a convenient means to simulate this reversion.

2.13 Look-Ahead

FSSIM tracks time in periodic increments. Because period length is typically set at more than one year, changes can occur within the period which could affect age-dependent factors such as achievement of minimum harvest age, group candidacy and forest cover constraint status. In order to account for this, FSSIM can project forward within a period to identify any age-dependent factors which could be affected by these changes. This functionality is called the *look-ahead*.

For example, at the beginning of a period the distribution of age classes within a zone may preclude harvesting due to the imposition of forest cover constraints, but growth during the period may alter this distribution and provide opportunities to harvest. Similarly, a forest class may be below minimum harvest age at the beginning of a period, but by the end of the period all or a portion of the class may be above this age. The look-ahead will permit harvesting in that portion of the class which will be equal to or above minimum harvest age at some point during the period.

Look-aheads are performed on minimum harvest age, green-up and old-growth ages. Look-ahead may be turned on or off for the simulation.



3.0 PROGRAM FUNCTIONALITY AND FLOW

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3.0 PROGRAM FUNCTIONALITY AND FLOW

This section discusses model functionality with respect to three processes, namely:

- Data entry (Section 3.1);
- Processing (Section 3.2); and
- Reporting (Section 3.3).

The new user should review this section in order to understand program function, use it as a guide to developing a data set, and refer back to it as an aid in trouble shooting.

3.1 Data Entry

The FSSIM data model is defined using a set of blank delimited ASCII files. Detail on the structure and content of these input files can be found in Appendix I. Simple numerical examples are provided here to assist the user in understanding the process.

Required data inputs are described first, followed by optional inputs which the user may employ to accommodate specific scenarios.

3.1.1 Simulation Time Horizon (required)

The simulation time horizon is read from *param.dat*. Also defined here is the length of individual periods to be used in the analysis and the length of time in which the model may look ahead at the state of the forest.

Usual simulation time horizons are 200 to 250 years. Longer simulations, up to 400 years, may be useful to evaluate long term trends in stock levels.

Look-Ahead defines the time period in which the model will assess future implications of modelling activity. Period Length and Look-Ahead should be the same unless the user has good reason for them being different, *e.g.* setting Look-Ahead to 0 is one way of switching look-aheads off.



Example: *param.dat*

```
Plan Horizon: 5
Period   Period Length   Look-Ahead
  1         10           10
```

In this example, the total planning horizon is 50 years (5*10). At the start of each period, the model will look ahead 10 years to determine changes in class status with respect to harvest, green-up and old-growth age specification.

3.1.2 Input Yield Curve Set Data (required)

Age-dependent yield tables are specified in the *vols.dat* file. Yield tables may be derived from any external source. The only requirement is that they be defined as ordered pairs of volume/age values. Ages must fall between 0 and 350, and one yield table must be specified for each analysis unit. Ages do not have to be at regular intervals (example: 10 years). FSSIM performs a linear interpolation between intervals to determine volumes at specific ages. For a particular table, the last volume specified is applied to all stands older than that age. A volume of 0.0 for age 0 is implicit.

Example: *vols.dat*

```
Table: 1
Age   Volume
 40    0.0
 50   80.0
100  200.0
```

```
Table: 2
Age   Volume
 30    0.0
 40   50.0
120  270.0
```

In this example, forest classes assigned to Analysis Unit 1 will have the following volume assignments:

- 200 cubic metres/ha if older than age 100.
- Volumes for forest classes between ages 0 and 100 will be determined through linear interpolation. For example, at age 90, a class will have a volume of 176 cubic metres/ha $\{80 + (40 * (200-80)) / 50\}$.



3.1.3 Input Operational Adjustment Factors (required)

Operational adjustment factors (OAFs) are used to scale yield table values. These are specified in the *oaf.dat* file and are used to adjust yields defined in *vols.dat*. In addition, the minimum harvest age (MHA) for stands using the specified volume table is specified in this file. All tables specified in *vols.dat* should have a corresponding entry in *oaf.dat*. If not, the table uses default values of MHA = $-\infty$ and OAF = 1.00. The volume table number is analogous to Analysis Unit number.

Example: *oaf.dat*

Table	MHA	OAF	OAF ²
1	81	0.90	
2	101	1.00	

The Yield curve values for Analysis Unit 1 are all reduced by 10% in this example. The minimum harvest age for forest classes assigned to Analysis Unit 1 is 81 years. Classes younger than this age have no harvestable volume. A 90 year old class will be assigned a volume of $176 * .9 = 158.4$ cubic metres/ha.

3.1.4 Input Forest Class Data (required)

FSSIM reads the starting forest inventory information from *class.dat*.

Each record in the file, referred to as a forest class, describes an area of forest stands in terms of the zone to which it belongs, the analysis unit which describes its growth pattern, and an age range to which it belongs. Age range is defined by two fields; lower age and upper age.

Each class is also designated a class type which describes the way in which the class will contribute to the analysis. Class type must be O,I,D,N or blank.

Class Type	Harvest Contribution?	FCC Contribution?	Specify Reversion Age?
(O)perable	Yes	Yes	No
(I)noperable	No	Yes	No
(D)eferred	No	Yes	Yes *
(N)on-contributing	No	No	Yes *

*Class types D and N revert to Operable when the reversion age is reached. Reversion age is only specified for class types D and N.



Example: *class.dat*

Zone	AU	LowerAge	UpperAge	Area	Class Type	ReversionAge
1	1	90	90	200.00	O	
1	2	10	10	20.00	I	
2	1	70	70	100.00	O	

In this example the total forest estate area is 320 hectares, of which 300 hectares are potentially harvestable (Operable). The remaining 20 hectares are classified as inoperable, and are not harvestable, although this area may be used in the calculation of green-up or old-growth forest cover requirements.

Note: If upper and lower ages are not equal, the class is evenly subdivided into 1-year classes at the start of the simulation.

3.1.5 Input Harvest Targets (required)

Annual harvest targets by period are read by FSSIM from the *targets.dat* file. Harvest target levels can be specified for ZONE or GROUP land units (Unit Type) and as VOLUME(m³) or AREA(ha) levels (Target Type). Different target types can be employed in the same simulation. ZONE = 0 always refers to the entire land base. Period indicates the first period in which the target is to apply. This target will apply for all subsequent periods in the planning horizon unless superseded.

Note: Zone 0 target must always be specified.

Example: *targets.dat*

```
Unit Type:  ZONE
Unit ID:    0
Target Type: VOLUME
Target
Period      1      1000.00
```

In this example, the target is to harvest 1 000 cubic metres/year from the operable forest starting in period 1.

The files described in Sections 3.1.1 - 3.1.5 contain the minimum amount of information necessary to complete an FSSIM analysis. In addition, the following files



(Sections 3.1.6 - 3.1.13) provide opportunities to specify additional simulation parameters.

3.1.6 Input Regeneration Assignments (optional)

In the minimal FSSIM data model just described, classes are assigned to the same analysis unit following harvest, with no regeneration delay. Optionally, FSSIM reads regeneration assignments from *regen.dat*. The pre and post-regeneration analysis units are defined in *regen.dat*, as are the percentage of the harvested area moving to any post-regeneration analysis unit, and the regeneration delay to be used. Regeneration percentages for a given ZONE/AU pair must add to 100.

If the file is present, FSSIM cross checks regeneration assignment against the yield table list in the *vols.dat* file. All zones, analysis units and regenerating analysis units specified in the *regen.dat* file must also be specified in the *vols.dat* data file.

Example: *regen.dat*

Zone	AU	PC	RAU	RDelay
1	1	100	2	4
1	2	100	2	4
2	1	100	2	4
2	2	100	2	4

In this example, 100% of the area of any forest class assigned to Analysis Unit 1 is assigned to Analysis Unit 2 following harvest, with a 4 year regeneration delay. If and when Analysis Unit 2 is harvested, it will be reassigned to Analysis Unit 2, again with a 4 year delay.

Note: It is important to explicitly define regeneration responses for all Zone/AU combinations (current or regenerating conditions), to avoid default assignments. In this example, if the regeneration response for AU 1 was not specified, the model would assign it back to AU 1 following harvest. Regeneration percentages for a given Zone/AU pair must add to 100.

3.1.7 Input Road Reduction Data (optional)

Maximum age of stands assumed to be roaded and reductions for areas removed from the harvesting land base for future road development are specified in the *roads.dat* file. Forest classes equal to or lesser than the specified age at time zero will not have road



reductions made to them. Other classes, after harvest by FSSIM, will be reduced in area by the road reduction factor.

Example: *roads.dat*

zone	Age	PC
1	31	5
2	31	5

In this example, FSSIM will remove 5% of the area of each forest class belonging to Zone 1 after harvest, provided the class was over age 31 at the start of the simulation.

3.1.8 Input Land base Factors (optional)

FSSIM reads and applies land base adjustment factors from the *landoaf.dat* file. Land base adjustment factors are applied to zones and AUs, with analysis units taking priority.

If zone is not specified then the OAF is applied to all the analysis unit occurrences across all zones. If zone but not analysis unit is specified then the OAF is applied to all AUs within the zone.

Example: *landoaf.dat*

zone	AU	LandOAF
1	n/a	.90
2	n/a	1.00

In this example, all areas within Zone 1 (regardless of AU) are reduced by 10% at the start of the simulation.

3.1.9 Input Group Data (optional)

FSSIM reads group data from the *group.dat* file, if one is present. Groups define areas bound together for analysis purposes. FSSIM allows two group types: (f)loat and (s)tatic. Area in a static group at the start of the planning horizon remains in that group throughout the entire planning horizon. On the other hand, a float group contains area that meets the group criteria either at the beginning of the period or at any time during the period. However, float group constituency may change as a result of aging, harvest, regeneration, transfers etc.

Note: This can lead to unexpected overlaps in group membership.



Program Functionality and Flow

Forest classes may be grouped for harvest targets, and/or the application of forest cover constraints.

Example: *group.dat*

Group	Type	Zone	AU	AgeLow	AgeHigh	CType
1	s	1	1	n/a	n/a	n/a
1	s	2	1	n/a	n/a	n/a

In this example, all AU 1 occurrences in both Zones 1 and 2 are grouped together. This permits the user to set harvest and/or forest cover constraint targets for AU 1.

3.1.10 Input Constraints (optional)

Forest cover constraint (FCC) data is read from the file *axs.dat*. Constraints are imposed at either the zone or group level. Constraints are either a maximum area depleted under a certain age (green-up), or a minimum retention of area equal to or above a certain age (old-growth). Each definition consists of the time frame (in simulation periods) in which the constraints will be applied, the age thresholds and the limits expressed as a percent.

Note: Age definitions in the grouping data may inadvertently exclude forest classes intended for inclusion. The definition of age ranges should be checked carefully to ensure that constraints are operating in the intended manner.

Example: *axs.dat*

UnitType	UnitID	Start	End	GUpAge	GUpPC	OGrAge	OGrPC
ZONE	1	1	5	n/a	n/a	140	11

In this example, an old-growth constraint is established for Zone 1. At least 11 percent of the area within the zone must be retained at or above age 140. If this constraint is violated at the start of the simulation, FSSIM will reserve sufficient area in the oldest age classes to make up the deficit. Any remaining area equal to or above minimum harvest age will be available for harvest.

3.1.11 Input Harvest Priorities (optional)

Zone, analysis unit and/or group harvest scheduling priorities by period are specified in the optional *priority.dat* file. Lower priority numbers have higher harvesting priority.



Example: *priority.dat*

Zone	AU	Group	Period	Priority
1	n/a	n/a	1	2
2	n/a	n/a	1	1

Zone 2 is assigned a higher priority than Zone 1 in this example. This will place all harvestable Zone 2 forest classes ahead of Zone 1 classes in the harvest candidate list. Within Zone 2, candidates will be ordered according to the harvest rule established. Priorities are established by period and remain in effect until superseded.

3.1.12 Input Zone Transfers (optional)

FSSIM reads zone or analysis unit transfers from the optional file *transfer.dat*.

If AU is included and does not exist in the specified Zone, an AU will be created to accommodate it and a transfer record will be attached to it.

Example: *transfer.dat*

UnitType	UnitID	Start	End	AgeLow	AgeHigh	Type ->	Zone	AU	Age	Type	RAge
AU	2	2	2	n/a	n/a	I	n/a	2	n/a	O	n/a

All forest classes assigned to AU 2 (I)nonoperable are transferred to (O)perable in period two. This mechanism can be used for a number of purposes, including Timber Licence reversions, conversion of non-commercial to commercial forest conditions, or the stocking of previously NSR conditions.

Note: Transfers occur at the beginning of the period, before any other processes.

3.1.13 Input Simulation Control Parameters (optional)

A number of control variables can be specified in the *config.dat* file. These specify options such as harvest rule, look-ahead, etc. This file is described in detail in Section 4.0.



3.2 Processing

This Section describes the processes which are followed in each iteration of the simulation. They are listed in the order in which they occur in the process.

3.2.1 Evaluate for end of Time Horizon

The plan horizon in periods is defined by the user in *param.dat*. After each iteration FSSIM tests for completion of the planning horizon and either commences the next iteration or exits the program.

3.2.2 Implement Zone/Analysis Unit Transfers

FSSIM implements zone or analysis unit transfers for the period. To apply this properly the user should be aware that transfers occur at the beginning of the period, before any other activities take place.

3.2.3 Determine Growing Stock (before harvest)

Growing stock is calculated for each forest class. In the case of the example data set, the calculation is as follows:

Zone	AU	Age	Volume vol/ha * OAF	Area area * LandOAF	Total Stock Volume * Area
1	1	90	176 * 0.9	200 * 0.9	28 512
1	2	10	0.0 * 1.0	20 * 0.9	0.0
2	1	120	200.0 * 0.9	100 * 1.0	18 000
Total				298	46 512

3.2.4 Create Harvest Candidate List

A harvest candidate list is created based on:

- Harvest priorities (if specified);
- Harvest rule;



- Merchantability based on minimum harvest age; and
- Operability based on class type.

Merchantability based on minimum harvest age includes look-ahead evaluation. Only class type = (O)perable classes are available for harvest.

In the example data, only AU 1 in Zone 2 is harvestable.

Zone	AU	(O)perable?	Above Min. Age?	Priority	Harvestable?
1	1	yes	no	2	no
1	2	no	no	2	no
2	1	yes	yes	1	yes

3.2.5 Harvest Forest

Harvest proceeds through the candidate list until the target is achieved or the list is exhausted. Harvest information is recorded in the *levels* files. In the example data, the harvest target was set at 1 000 m³/year, or 10 000 m³/period.

Zone	AU	Area Cut (ha)	Volume Cut (m ³)	Harvest Age
1	1	0	0	n/a
1	2	0	0	n/a
2	1	55.56	10 000	120
Total		55.56	10 000	

3.2.6 Process Roads

FSSIM reduces all harvested classes by a road reduction percentage, controlled at the zone level. In the example, 5% of the area harvested in AU 1 was considered to be roaded, and permanently removed from the land base.



Program Functionality and Flow

Zone	Road %	AU	Above Roaded Age?	Area Cut	Area In Roads
2	5	1	yes	55.56	2.78

3.2.7 Regeneration

Linkages are provided in *regen.dat* to redistribute forest classes to post-harvest analysis units and include the appropriate regeneration delay. After harvest, all harvested forest classes are reassigned to their appropriate post-harvest analysis unit(s).

Zone	Precut AU	Regen AU	Regen Delay
2	1	2	4

3.2.8 Grow Forest

If aggregation is turned on (see Section 4.5) FSSIM aggregates post-harvest forest classes based on parent zone, age, analysis unit and group membership.

All class ages are then incremented by period width.

Group membership is reassigned for all FLOAT type groups. STATIC group membership is only assessed at time zero (beginning of planning horizon before any aging takes place).

FLOAT type groups use look-ahead for membership. If the class ages into the group, group membership is affected. In the example, the following changes in stock take place during the first period.

Zone	AU	Old Age	Old Area	- harvest	- roads	New Area	New Age	Volume
1	1	90	180	0	0	180	100	32 400
1	2	10	18	0	0	18	20	0
2	1	120	100	-55.56	0	44.44	130	8 888
2	2	0	55.56	0	-2.78	52.78	10	0



3.3 Reporting

FSSIM opens the following report files to record simulation results.

Overall harvest levels achieved	<i>levels.rep</i>
Zone harvest levels achieved	<i>levels.zon</i>
Group harvest levels achieved	<i>levels.grp</i>
Constraint levels implemented	<i>constraints.rep</i>
Road areas removed	<i>roads.rep</i>
Land base; area	<i>land_ha.rep</i>
Land base; volume	<i>land_m3.rep</i>
Land base; area(zone)	<i>land_ha.zon</i>
Land base; volumes(zone)	<i>land_m3.zon</i>
Land base; area(group)	<i>land_ha.grp</i>
Land base; volume(group)	<i>land_m3.grp</i>
Growing stock area	<i>stock_ha.rep</i>
Growing stock volume	<i>stock_m3.rep</i>
Growing stock area(zone)	<i>stock_ha.zon</i>
Growing stock volume(zone)	<i>stock_m3.zon</i>
Growing stock area(group)	<i>stock_ha.grp</i>
Growing stock volume(group)	<i>stock_m3.grp</i>
Harvest age	<i>hage.rep</i>
Harvest age(zone)	<i>hage.zon</i>
Harvest age(group)	<i>hage.grp</i>
Class type reversions	<i>reversion.rep</i>
Transfers	<i>transfer.rep</i>

Output file details are contained in Appendix II.

The new FSSIM user will find the following reports most useful:

constraints.rep Zone/Group constraints status by period to determine when and where harvest availability is being limited.



<i>stock_m3.rep</i>	Total, Operable, Merchantable and Available Volume by period and age class before and after periodic processing. Valuable for monitoring growing stock availability for sustainability.
<i>levels.rep</i>	Harvest area and volume and road area reported by period to check achievement of goals.

3.3.1 Forest Inventory Status (before and after harvest)

Land Base Reports

land_ha
land_m3

FSSIM reports total, operable, inoperable, deferred and non-contributing land base by age class and period. *land_ha* provides area in hectares, while *land_m3* provides volume in m³.

Growing Stock Reports

stock_ha
stock_m3

These reports summarize growing stock volume (*stock_m3*) and area (*stock_ha*) in the operable land base.

Land base and growing stock reports are all available in three resolutions:

- for the entire land base (**.rep*);
- by zone (**.zon*); and
- by group (**.grp*).

3.3.2 Report Constraints (before and after harvest)

Forest cover constraint targets and current levels before harvest simulation are written to the *constraints.rep* file before any harvesting occurs and after harvest is completed.



3.3.3 Report Harvest Levels

Harvest targets (volume and area) and levels achieved are reported.

Report File: *levels.rep*
levels.grp
levels.zon

3.3.4 Report Harvest Ages

Reports volume and area-weighted harvest ages and distribution.

Report File: *hage.rep*
hage.zon
hage.grp



4.0 RUNNING THE PROGRAM

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4.0 RUNNING THE PROGRAM

The UNIX version of FSSIM consists of one executable file. The program is run with the path to the data files as its parameter. The executable may reside anywhere in the file system if a path to it has been declared.

Execution of FSSIM includes specification of a data directory. FSSIM creates a reports sub-directory (if one does not already exist), in the directory containing the data input files and then creates an output file, *log.out*, within the reports directory to record all screen information, including warning and error messages. If there are any errors creating or opening these files the system will halt. Figure 4.1 is an example of the directory structure. The Windows application allows the user to define directory locations.

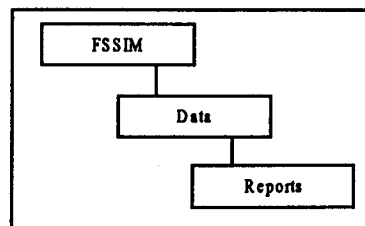


Figure 4.1 – Directory Structure

Note: The subdirectory containing the data model can have any valid directory name, and can reside anywhere in the directory system.

The *config.dat* file controls program execution. If no *config.dat* file is present, program defaults will be employed.



The following is an example *config.dat* file:

```
Harvest Rule [1..4]:          1
Initial Age Offset [years]:    0
Report Class Width [years]:    10
Look-Ahead [On/Off]:          On
Aggregation [On/Off]:          On
Report Headers [On/Off]:       On
Randomizer [On/Off]:           Off
Randomizer Seed [integer]:     1024
Reports [On/Off]:              On
```

The configuration file is an ASCII text file that sets up the simulation environment. On start up FSSIM reads this file and depending upon its contents initiates processing and/or sets global memory variables. The field label text up to and including the colon must appear exactly as specified. Not all parameters need to be included in the *config.dat* file. Those parameters not in the file will be assigned the FSSIM default values listed below. The order in which the parameters occur in the file are not important.

4.1 Harvest Rule

Default: Absolute Oldest First(1)
Possible: Absolute Oldest First(1)
Relative Oldest First(2)
Absolute Youngest First(3)
Random(4)
Text Label: Harvest Rule [1..4]:

Comments:

The harvest rule is used to determine the position of each class in the harvest candidate list.



Running the Program

Rules 1 and 3 order forest classes respectively in descending or ascending order of age. Relative oldest first considers the difference between age and minimum harvest age (see also Section 2.9).

Rule 4 brings forest classes into the harvest candidate list in random order. If this rule is used, the random toggle must be enabled (Section 4.7) and a random seed specified (Section 4.8).

4.2 Age Offset

Default: 0
Possible: Any positive Integer Value.
Text Label: Initial Age Offset [Years]:

Comments:

This parameter specifies the number of years to offset the initial forest class ages in *class.dat*. An initial offset of 5 would add 5 years to the age of all forest classes prior to the start of the planning horizon. This age offset occurs only once. Entries in *class.dat* are not affected, and all changes are internal to the FSSIM data structures.

4.3 Report Class Width

Default: 10
Possible: Any positive Integer Value
Text Label: Report Class Width [Years]:

Comments:

This parameter specifies the width of age intervals to use for inventory reporting. A report class width of 10 years generates reports with age intervals[1-10;11-20;21-30;...] while a report class width of 5 years will generate inventory reports with age intervals[1-5;6-10;11-15]. This value is used for reporting only and does not affect processing or calculations. Changing the report class width will not impact results.



4.4 Look-Ahead Toggle

Default: OFF
Possible: ON Enable period look-ahead
OFF Disable period look-ahead

Text Label: Look-Ahead [On/Off]:

Comments:

Look-aheads are performed on minimum harvest ages, green-up ages and old-growth ages to account for in-period changes of age status. See also Section 2.13.

4.5 Extract Aggregation Toggle

Default: OFF
Possible: ON Enable post-harvest aggregation
OFF Disable post-harvest aggregation

Text Label: Aggregation [On/Off]:

Comments:

When post-harvest aggregation is enabled, FSSIM will aggregate similar forest classes together after harvest. This allows FSSIM to use less memory and therefore run faster. Forest classes are considered similar if they match on age, parent zone and AU, class type, and group membership.

4.6 Report headers

Default: ON
Possible: ON Enable report headers
OFF Disable report headers

Text Label: Report Headers [On/Off]:



4.7 Random Toggle

Default: OFF
Possible: ON Enable randomizer
OFF Disable randomizer
Text Label: Randomizer [On/Off]:

4.8 Random seed toggle

Default: 1
Possible: Any positive Integer Value
Text Label: Randomizer Seed [integer]:

4.9 Reports

Default: On
Possible: On Generate all reports
Off Generate only levels reports.
Text Label: Reports [On/Off]:



5.0 SAMPLE DATA SET AND SIMPLE ANALYSIS SCENARIO

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Sample Data Set

5.0 SAMPLE DATA SET AND SIMPLE ANALYSIS SCENARIO

A simplified FSSIM data model has been developed to demonstrate the approach, as well as to provide a data set for the user to explore the simulation methodology. The actual contents of the data files are described in Appendix I. In each section, the relevant FSSIM data files are referenced.

5.1 Land base Definition

A total of 48 910 hectares of productive forested lands were identified on this land base.

This area was classified as shown in the table below.

Category	Criteria	Non-commercial	Non-harvest (class type = D)	Harvestable Area (class type = O)
Non-commercial	Type ID (projected) = 5	721		-
Inoperable	Operable class = I		1 279	
Roads	10 metre road width allowance	267		-
Streams	30 metre buffer		1 803	-
ESA1	ESA1 = P (sensitive soils)		93	-
Problem types	Site index below poor analysis unit minimum		14 461	-
Deciduous	Inventory type group > 34		6 172	-
Net Operable	Not previously excluded			24 114
Total		988	23 808	24 114



5.2 Analysis Unit definition and yield table development (*vols.dat*)

Analysis units were developed based on combinations of leading species and site productivity. Yield tables were developed for existing natural stands (VDYP) and future managed stands (TIPSY). Managed stands include all existing stands less than age 5, as well as all future regeneration. The following parameters were used to develop yield tables:

Stand model: VDYP
 FIZ: L
 PSYU: 0192
 Utilization: 17.5 cm (spruce), 12.5 cm (pine)

Stand model: TIPSY
 Regeneration: planted
 Density: 1 500 trees/ha
 Utilization: 12.5 cm (all species)
 Regeneration delay: 0 years (a 4 year delay will be modelled in FSSIM)

Analysis unit assignment criteria are summarized in the table below.

Unmanaged Analysis Unit	Managed Analysis Unit	Name	Inventory Type Group	Site Index Range	Minimum Age	
					VDYP	TIPSY
1	101	Pine - good site	27-34	< 12.00	100	80
2	102	Pine - medium site		12.00-13.99	110	100
3	103	Pine - poor site		14.00+	120	110
4	104	spr/bal - good site	18-26	< 9.50	100	100
5	105	spr/bal - medium site		9.50-11.99	120	120
6	106	spr/bal - poor site		12.00+	150	150



5.3 Grouping (*group.dat*)

The land base is subdivided into two landscape units. Within each landscape unit, specific visual quality zones have been established. Green-up objectives are to be achieved within the visual quality categories identified in each landscape unit. Groups are established containing the (O)perable component within each zone. In addition, biodiversity objectives in the form of seral stage requirements, are to be established at the landscape unit level. This second tier of forest cover constraints requires that groups be established corresponding to each landscape unit, and including all of the zones within each landscape unit. As biodiversity considers both operable and inoperable components of the forest, both are included in the biodiversity groupings. These are also shown in the following table. The numbering of groups and zones is arbitrary. The particular numbering scheme used in this example facilitates interpretation later in the analysis.

Bio-diversity Group #	VQO Group #	Zone #	Landscape Unit #	Visual Quality Objective		Class type = I no harvest	Class type = O harvestable
				#	VQO objective		
70	72	72	7	2	partial retention	395	787
70	73	73		3	modification	450	739
70	74	74		4	none	9 509	10 229
80	82	82	8	2	partial retention	989	809
80	83	83		3	modification	1 183	729
80	84	84		4	none	11 282	10 821
Total						23 808	24 114

5.4 Forest Cover Constraints (*axs.dat*)

Biodiversity requirements are based on the BWBS biogeoclimatic unit (Natural disturbance type 3). These are to be met at the landscape unit (GROUP) level, based on forest cover in both the harvestable (class type = O) and non-harvestable (class type = I) components of the productive forest. They are summarized in the following table.



Landscape Unit #	Biodiversity Emphasis	Early seral stage		Mature + Old seral stage		Old seral stage	
		Age	%	Age	%	Age	%
7	intermediate	≤40	≤54	≥100	≥23	≥140	≥11
8	intermediate	≤40	≤54	≥100	≥23	≥140	≥11

Green-up requirements (see the table below) are based on visual quality objectives, and must be achieved within each zone. They are to be based on the harvestable (class type = O) component only.

Visual Quality Objective	Green-up Age	Maximum percent below green-up
Partial Retention	28	13
Modification	28	24
None	20	33

5.5 Age Class Assignment (*class.dat*)

Forest stands were aggregated into 10 year age classes as follows:

lower age	upper age
1	10
11	20
21	30
etc.	

Existing NSR was assigned an age of -5, based on the assumption that it would be restocked during the next 5 years.



5.6 Future Road Allowances (*roads.dat*)

For analysis purposes, it was assumed that all classes less than or equal to age 31 at the start of the simulation have already been roaded. The remaining areas are reduced by 5% following harvest to account for future roading.

5.7 Forest Class Assignment (*class.dat*)

All forest stands were aggregated into forest classes based on having the following characteristics in common:

- Zone;
- Analysis unit;
- Age class; and
- Class type.

5.8 Regeneration (*regen.dat*)

All classes currently assigned to unmanaged analysis units (1-6) are converted to the managed analysis unit counterparts (101-106) following harvest. Managed classes revert to the same analysis unit following harvest. A four year regeneration delay is assumed in all cases.

5.9 Land base and Yield Reductions (*oaf.dat, landoaf.dat*)

No further reductions were assumed (*i.e.* land base and yield table OAFs were all set to 1.0). Minimum harvest ages (see Section 5.2) were also defined in the *oaf.dat* file.

5.10 Harvest Priorities (*priority.dat, config.dat*)

Priorities were established on a zonal basis. Lowest priority (100) was assigned to zones with no visual quality objectives. Modification VQOs were assigned a higher



priority (99), with partial retention VQOs given the highest priority (98). Within each zone it was assumed that the oldest stands would be harvested first (harvest rule 1).

5.11 Harvest Target (*targets.dat*)

An initial harvest target of 42 000 cubic metres per year was established. This target is applied to the entire harvestable land base.

5.12 Simulation Results

The FSSIM sample database which was developed based on the preceding assumptions is documented more fully in Appendix I. The user can employ this dataset to develop an understanding of the simulation methodology, and the forest dynamics associated with the sample landbase.

The output files generated by running this dataset are described more fully in Appendix II. While provision of an FSSIM tutorial is beyond the scope of this manual, users are encouraged to run FSSIM using this sample dataset, and examine the simulation results contained in the output files created in the REPORTS subdirectory. The following results are worthy of note:

1. The target harvest level (42 000 cubic metres/year) is attained in all periods (see the *levels.rep* file).
2. The supply of merchantable timber drops to a minimum of approximately 1.1 million cubic metres in periods 12-15 (see the *stock_m3* files). It then increases to a level of approximately 1.6 million by iteration 18, and remains stable to the end of the simulation time horizon. The user should experiment with different harvest target levels by editing the *targets.dat* input file, in order to observe the impact on available timber.
3. The total area of the forest drops from 47 922.42 hectares in period 1, to 46 784.65 hectares in period 24 (see the *land_ha* report files). This represents a loss of 1 137.77 hectares of harvestable land, and is due to the impact of future roading. The user can confirm this by examining the *levels.rep* and *roads.rep* files.
4. Average harvest age drops abruptly in period 14, as harvesting shifts from predominantly old-growth stands to second growth (see the *hage.rep* file). As this



Sample Data Set

also coincides with the point when available timber minimizes, it is clear that the supply is being constrained by the availability of harvestable second growth stands.

5. Examination of the *constraints.rep* file shows that the green-up constraints for zones 82 and 83 are in violation at the start of the simulation. This prevents harvesting in these zones in period one (see *levels.zon*). While the constraints file indicates that these zones are still in violation in period two, harvesting does in fact occur. This is due to the look-ahead mechanism which determines that some of the disturbed area will achieve green-up during the period. The user should experiment with different constraint levels to determine the sensitivity of timber supply.
6. The *levels.zon* file serves to demonstrate the effect of the harvest priorities specified in the *priority.dat* input file. Zones 72, and 73 are harvested heavily in the first period. Examination of the *constraints.rep* file indicates that further harvesting in Zone 72 would violate the green-up constraint.

Users are encouraged to run different scenarios by altering the contents of the input files, and then examining the resultant report files. In order to properly understand cause and effect relationships in each scenario, it is important to alter inputs only at a time, documenting these changes as well as their impacts on forest performance.



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6.0 "HOW TO" HELP PAGES

The following are modelling applications that may be required when developing a harvest schedule using FSSIM. This information is provided to assist the user in formulating data inputs, and to provide model instructions for developing more meaningful analysis results.

Many assignments to the FSSIM input data may be performed more efficiently in an external database manager. Outputs from this environment can then be used as input files for FSSIM.

6.1 Landscape Unit Definition

The Forest Practices Code Biodiversity Guidebook outlines the requirement to identify "landscape units" as a key component for managing biodiversity. Once landscape units have been delineated at the mapping level and included in the analysis data set it is possible to model the recommended seral stage distributions outlined in the Biodiversity Guidebook.

Use of "Groups" in FSSIM will facilitate the modelling of landscape unit biodiversity while maintaining the underlying management zone (e.g. VQOs, wildlife habitat, riparian management zones) forest cover constraints that are required in the simulation. Groups do not need to be numbered sequentially within the analysis input data. Group numbers may be as high as 999 999 999. This provides a significant amount of flexibility for organizing input data by Groups.

It is important to consider the organization of landscape units, management zones, and any other aggregation of the inventory prior to assigning groups. It will be much easier to identify and track activity in each of the aggregation Groups before, during, and after the simulation has been completed. Some analyses to date have included over 2 500 Groups relating to landscape units, management zones, and natural disturbance types (NDTs).

The following steps outline one approach to grouping forest inventory into landscape units for analysis with FSSIM. This approach assumes that landscape units have been mapped and included in the timber supply analysis database.



1. Determine the number of landscape units identified in the analysis database, example of 4.
2. Determine the number of management zones that occur in the analysis database, example of 7.
3. Therefore, as many as 28 ($4 * 7$) landscape unit/management zone combinations may be present.
4. It is often difficult to track individual landscape unit management zone aggregations if numbering of these aggregations is sequential from 1 upwards. To facilitate recognition, management zones are numbered from 1 to 7 and then combined with the landscape unit number within which they lie, to form a unique FSSIM zone number. For example, FSSIM Zone 12 would represent the combination of landscape unit 1, and management zone 2.
5. If all management zones are present in every landscape unit there will be FSSIM zones numbered (non consecutively) from 11 to 47.
6. Groups identifying landscape units are defined in the *group.dat* file. Each group will have an associated list of FSSIM zones which fall within the group. For example, Group 10 would include FSSIM Zones 11-17, and Group 20 would include FSSIM Zones 21-27.

Assigning seral stage targets to landscape units is explained in the following section.

6.2 Seral Stage Distribution

Seral stage distribution is an important objective for maintaining biodiversity at the landscape unit level. The Forest Practices Code Biodiversity Guidebook lists seral stage distribution for each NDT within the province. Distributions are included in FSSIM simulations by specifications presented in the *axs.dat* file.

Landscape units are commonly defined by "Groups" as outlined above. Therefore in the *axs.dat* file seral stage distributions will be assigned to each group using UnitType "GROUP". Seral stage distributions may include typical "early", "mature", and "old" targets or further subdivisions of these categories.



For example the recommended seral stage distribution for the SBS biogeoclimatic unit in NDT3 (landscape unit group 10) with the high emphasis for biodiversity option requires:

- Maximum 40% of the productive forest less than 40 years (early);
- Minimum 34% of the productive forest greater than 100 years (mature); and
- Minimum 16% of the productive forest greater than 140 years (old).

In the *axs.dat* file these distributions are included as:

UnitType	UnitID	Start	End	GUpAge	GUpPC	OGrAge	OGrPC
GROUP	10	1	25	40	40	100	34
GROUP	10	1	25	n/a	n/a	140	16

The seral stage distributions may be included on a number of entries (lines) within *axs.dat*. As presented here the early and mature targets are included on one entry and the old target is included on a second entry. All targets that are defined by a minimum age are included in the OGrAge and OGrPC columns of *axs.dat*.

FSSIM will not permit harvesting to continue within a group if the green-up maximum for that group cannot be exceeded. Harvesting may continue in situations where the targets defined by the OGrAge and OGrPC categories are not achieved. This is done by "reserving" the oldest area within the group and allowing harvest in the remaining area that is older than minimum harvest age within the same group. The look-ahead feature (Section 2.13) outlines this feature in greater detail.

6.3 Stand Level Biodiversity

Stand level management works in conjunction with landscape level management to maintain biodiversity. "Wildlife tree patches" (WTPs) and "individual tree retention" are two approaches used operationally to accommodate stand level biodiversity objectives. Identifying the exact location of WTPs is uncommon when preparing the inventory data for timber supply analysis. Therefore, percentage reductions are used to reflect the loss of harvestable timber due to these biodiversity requirements.



The Biodiversity Guidebook outlines the recommended cutblock percentages that should be retained based on a number of criteria including past harvesting and percentage of area available for harvest. These recommended percentages can be included in the FSSIM *oaf.dat* file to reflect stand level biodiversity requirements. It is more suitable to use a volume reduction for stand level biodiversity rather than a land base reduction in the *landoaf.dat* file. Use of land base reductions will alter the forest cover constraint calculations in an unrealistic manner.

6.4 Timber Licence Reversions

Timber Licence (TL) reversions are the transfer of land classified as non-Crown back to the Crown after harvesting has been completed on the Licence. The land then becomes part of the working forest associated with the remaining Crown land in the land base (either TSA or TFL).

TL reversions can be modelled in FSSIM using specific attributes in the *class.dat* file. To identify an entry in the *class.dat* file as a candidate for reversion, two fields — "class type" and "reversion age" are given special inputs.

Any land scheduled for reversion must be included in the *class.dat* file and have all of the necessary classification attributes, including:

- Zone;
- Analysis unit;
- Lower and upper age;
- Area;
- Class type = D; and
- Reversion age - set to the age (in years) when the forest class reverts to a new class type.

At reversion age forest classes with class type D will shift to class type (O)perable and begin contributing to both annual harvest and forest cover constraint assessments.

Private land additions to tree farm licences and rehabilitation of non-commercial/non-stocked lands to the productive forest are other common land base reversions that may



be modelled using the same technique in FSSIM. The *transfer.dat* file can also be used to model reversions.

6.5 NSR Restocking

Current forest legislation requires that most NSR areas return to a fully stocked condition within a prescribed time frame. FSSIM considers delays associated with achieving stocked status and models them appropriately during the simulation.

NSR areas are included in the *class.dat* file in the same way as all other productive forest stands. All attributes must be assigned for the following:

- Zone;
- Analysis unit;
- Lower and upper age;
- Area; and
- Class type = O.

For areas classified as NSR that are included as forest classes in the *class.dat* file the lower and upper ages are set at the negative value of the regeneration delay expected for the NSR.

For example if a given NSR forest class is expected to take 4 years to achieve fully stocked status, the lower and upper ages are set at "-4". Four years into the FSSIM simulation the NSR is considered stocked and growth will reflect the yield curve to which the forest class was assigned (by way of its analysis unit assignment).

As an alternative, if the expectation is that the NSR associated with a given zone and analysis unit will become stocked in equal amounts over the first five years of the simulation the following approach may be used. Assign -5 as the "lower age" and -1 as the "upper age". FSSIM will then distribute the forest class into five equal components with ages -1 through -5. During the simulation these five land base components will achieve a stocked condition (age 0) during the first five years. This approach is useful for regenerating backlog NSR areas which may become stocked gradually over a specified number of years.



6.6 Yield Sensitivity

Yield estimates included in timber supply analysis may not reflect what is obtained from harvesting during actual forest operations. To test the impact of yield adjustments (both upwards and downwards) on timber supply a change to the information in the file *oaf.dat* is made.

The field "OAF" in *oaf.dat* is modified from a default value of 1.00 to some other value. For example an OAF of 0.90 for a given yield table will adjust all volumes downwards to 90% of their original values. Similarly, an OAF of 1.15 will adjust all volumes upwards to 115% of their original values.

OAFs are required for each yield table included in the simulation data set. However OAFs may be different for each yield table. The use of OAFs in *oaf.dat* makes adjustments to yields straightforward. This technique also avoids the additional effort associated with developing new yield tables for different scenarios being evaluated in a timber supply analysis.

6.7 Land base Sensitivity

As with yield tables there may be uncertainty associated with the area that should be included in the analysis land base. It may be a significant exercise to generate a completely new *class.dat* file to reflect a minor adjustment in area contributing to timber supply. The file *landoaf.dat* may be used to make adjustments to some or all of the forest land base.

Increases or decreases to the land base are made by modifying the LandOAF field in *landoaf.dat* from the default of 1. As with the *oaf.dat* file values greater than 1 will increase the land base; values less than 1 will decrease the land base.

LandOAF values are assigned to zone/analysis unit combinations. If only the zone is specified then all analysis units within that zone are adjusted by the LandOAF.

It is important to note that adjustments made by including the *landoaf.dat* file will increase or decrease all areas within the *class.dat* file which meet the zone/analysis unit identification. If a shift of land base from operable forest to inoperable is desired to evaluate additional riparian reserves or wildlife tree patches then the *landoaf.dat*



methodology is not suitable. These types of adjustments are more suited to generation of a new class file or use of the *transfer.dat* file.

Note: Land OAFs are applied only at the start of the simulation.

6.8 Faster Processing

With complex data sets and simulations of up to 40 periods, the processing time for an FSSIM simulation may become very long. This is especially true if there are any computer hardware limitations. Below are some ways to improve the processing time for FSSIM simulations.

In the *class.dat* file set the LowerAge = UpperAge. This will avoid splitting the forest class information excessively. If the difference between LowerAge and UpperAge is 10 years (to represent 10 year age classes in the inventory) the *class.dat* file is increased by a factor of 10. Forest classes are split during the simulation process so avoiding any additional disaggregation of forest classes will improve processing time. There is however, an attendant loss in resolution.

Setting the "Aggregation" flag in *config.dat* to "on" will improve processing by aggregating all similar forest classes after each period of the simulation.

Turning reports "off" in *config.dat* during preliminary simulations will allow faster compilation prior to generating the full set of reports. Report generation occurs during each period of the simulation. In addition, reports can use up considerable disk space if the data model used in the simulation is large and/or complex.

Minimize the group/zone/analysis unit combinations. This will need to be balanced with the need for obtaining reasonable outputs for interpretation. If the data model is too complex processing time will be limiting. However, if the data model is too simple the results will not provide sufficient detail for developing an understanding of the timber supply picture for the study area.



7.0 GLOSSARY

allowable annual cut (AAC): The approved rate of timber harvest from a specified area of land. The Chief Forester of B.C. sets AACs for Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) in accordance with Section 7 of the Forest Act.

analysis unit: A biologically based grouping of like forest stands used as the basis of aggregation of inventory and description of stand yield. Stands are assigned to analysis units to minimize modelling complexity yet maintain resolution by separating differences in productivity or growth pattern.

base case: A description of current forest conditions and management assumptions modelled to evaluate short and long term harvest flow under a *status quo* scenario.

basic silviculture: Stand treatments that are carried out to ensure the establishment of a free-growing crop.

biodiversity (biological diversity): Diversity of life in all its forms and levels of organization, including genes, species and ecosystems and the evolutionary and functional processes that link them.

cover requirements: In wildlife habitat management, the particular needs of a wildlife species for cover or shelter.

cutblock adjacency guidelines: Integrated management guidelines that specify the desired spatial relationships among cut blocks. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.

deferred (D): In FSSIM, deferred forest classes are non-contributing harvest until such time as they are reclassified. They do contribute to forest cover constraint calculations.

dbh (diameter breast height): The stem diameter of a tree measured at breast height, about 1.3 metres above the point of germination.

economically operable: Stands for which log prices exceed harvesting costs, including profit and return to capital.



Glossary

even flow: In harvest scheduling, the requirement that the harvest level in each period be equal to the harvest level in the preceding period.

falldown: The difference in allowable cut between that in a timber surplus situation and the level of long run harvest level.

forest class: The smallest unit of forest land in an inventory as input to a forest level model, usually an aggregation of forest stands of the same analysis unit, age and management zone.

forest cover constraints: In forest level modelling, management for resources and products other than timber can be related to restrictions on the harvest of forest cover. Minimum or maximum constraints are imposed on retention or harvest respectively.

forest estate model: An analytical computer based model that successively harvests and grows collections of forest stands over an extended period according to specific data and management assumptions. Simulation models determine the effects of a specified management policy. Optimization models seek out the policy or management alternative that best attains a specified management objective subject to defined constraints.

free growing: An established seedling or forest stand of an acceptable commercial species that is free from growth-inhibiting brush, weed or excessive tree competition.

FSSIM: The forest management simulation model (Forest Service Simulator) developed by the B.C. MoF for use in the process of determining allowable harvest levels.

green-up period: The time needed for a stand of trees to reach a desired condition (usually height) to ensure maintenance of water quality, wildlife habitat or other management goal.

group: In FSSIM, forest classes of any combination of zones and analysis units can be organized into groups based on any management requirement. Forest cover constraints and/or harvest targets may be applied to this group.

harvest forecast: The flow of potential timber harvests over time. Usually a maximum timber supply for as specified land base and set of management assumptions.

incremental silviculture: Stand treatments carried out to maintain or increase the yield and value of forest stands, over and above basic silviculture.



inoperable (I): In FSSIM, inoperable forest classes contributing to FCC but not harvest. No reversion age is specified for D types.

IRM (integrated resource management): Integrating the use and protection of timber and non-timber resources and environmental values.

landscape unit: A planning area based on topographic or geographic features such as watershed or series of watersheds.

LRSY (long run sustainable yield): A maximum theoretical level of productive capability of a land base for a certain management regime.

LTHL (long term harvest level): The actual harvest level which potentially can be achieved given the imposition of management constraints.

MAI (mean annual increment): The average annual increase in volume of individual trees or stands up to a specified point in time. Maximum MAI is commonly used to identify biological maturity.

management assumptions: Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest estate model.

minimum harvest age: In forest modelling, the age at which a forest class becomes available to harvest.

non-contributing (N): In the context of contribution to analysis, non-contributing forest classes contribute to neither harvest or forest cover constraints.

operable (O): In the context of contribution to analysis, operable forest classes contribute to both forest cover constraints (FCC) and harvest.

pass: One of a planned sequence of harvesting operations designed to log a management unit over an extended period of time in discrete phases, so that the area harvested at any one time does not exceed specified limits.

simulation model: A computer based model which forecasts changes in forest structure by successively harvesting and growing collections of forest stands to determine the effects of a specified management policy.

site index: A measure of site productivity, expressed as stand height at some reference age, usually 50 years.



sustained yield: An approach to forest management which calls for an approximate balance between net growth and amount of timber harvested from an area.

timber harvesting land base: The portion of the total land area of a management unit considered to contribute to, and be available for, long term harvesting.

TIPSY (table interpolation program for stand yields): A MoF computer program for generating managed stand yields.

TSA (timber supply area): An area of land designated as an integrated resource management unit and being (along with TFLs) the control area for determining and controlling allowable harvests. A number of volume based licences are normally included within a single TSA.

TFL (tree farm licence): An area based form of tenure which is designed to encourage the long term practice of sound forest management on Crown and private lands. TFLs (and TSAs) are the control area for determining and controlling allowable cuts. Forest management on TFLs is granted to a single licence holder with exclusive rights to timber resources.

utilization standard: The dimensions (stump height, diameter breast height (dbh) and top diameter inside bark) of trees that are deemed merchantable and must be cut and removed from Crown land harvesting operations.

VDYP (variable density yield projection): An MoF computer program for generating natural stand yields based on empirical data.

VQO (visual quality objective): Acceptable level of alteration of the visible landscape by forest management practices.

watershed: An area of land that collects and discharges water into a single main stream through a series of smaller tributaries.

zone: In FSSIM, zones are defined on the basis of similarity of management objectives, and spatial proximity. Applied at the zone (or at the group) are forest cover constraints to model integrated resource management.



APPENDIX I - INPUT FILE STRUCTURES

Figure AI.1 presents the input files organized by theme to assist in their preparation.

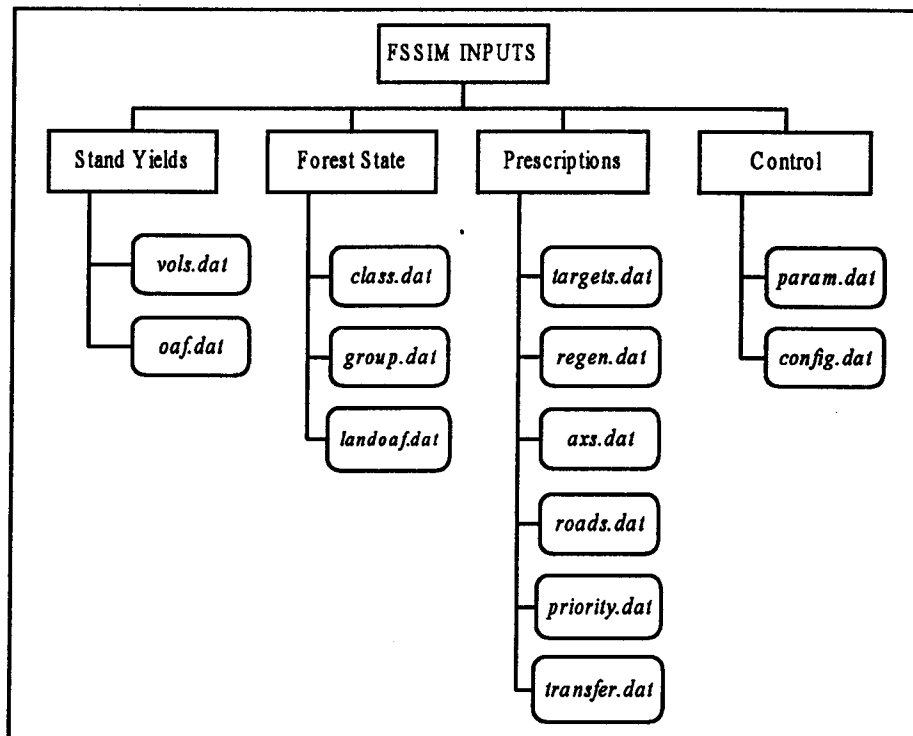


Figure AI.1 Input Files



Input Files

I.1	<i>vols.dat*</i>	Yield tables
I.2	<i>oaf.dat*</i>	Operational adjustment factors to adjust yields
I.3	<i>class.dat*</i>	Provides the forest inventory data
I.4	<i>group.dat</i>	Areas grouped together for analysis purposes
I.5	<i>landoaf.dat</i>	Land operational adjustment factors
I.6	<i>targets.dat*</i>	Harvest levels
I.7	<i>regen.dat</i>	Regeneration rules
I.8	<i>axs.dat</i>	forest cover constraints
I.9	<i>roads.dat</i>	Road reductions
I.10	<i>priority.dat</i>	Harvest priorities
I.11	<i>transfer.dat</i>	Class movements between ZONEs or GROUPs
I.12	<i>param.dat*</i>	Basic planning horizon parameters

The data files are fixed length blank delimited ASCII files used as input to FSSIM. Not every data file needs to be used in the simulation. The required files are indicated by *.

With the exception of the *config.dat* file which was outlined in detail in Section 4, each of the input data files is described in the sections which follow. Descriptions include sample record listings. Files have required and optional fields. Required but unused fields must have "n/a" as a place marker.

Note: Each file has an attendant set of column headers. These headers must be included exactly as they appear in the file descriptions. Upper and lower cases must be employed as indicated. Column headers must be separated by at least 1 space.



I.1 Volume Tables – *vols.dat* (sample records only)

Table: 1
 Age Volume
 10 0.00
 20 0.00
 30 0.00
 40 7.20
 50 41.44
 60 74.60
 70 106.24
 80 136.30
 90 165.12

This file provides the yield (volume) curve coordinates for each yield table. Each table corresponds to analysis unit (AU) designation in the *class.dat* file.

Header/Label	Details	Type	Required?
Table	Table ID	Integer	Yes
Age	Age in years	Integer	Yes
Volume	Volume in m ³	Float	Yes

I.2 Volume Reduction Factors – *oaf.dat*

Table	MHA	OAF	OAF2
1	100	1.00	
2	110	1.00	
3	120	1.00	
4	100	1.00	
5	120	1.00	
6	150	1.00	
101	80	1.00	
102	100	1.00	
103	110	1.00	
104	100	1.00	
105	120	1.00	
106	150	1.00	

In addition to the minimum harvest age for stands using the volume table defined by Table ID, the *oaf.dat* file contains operational adjustment factors used to adjust yields defined in *vols.dat*. All tables specified in *vols.dat* should have a corresponding entry in *oaf.dat*; if not, the table uses default values of MHA = $-\infty$ and OAF = 1.00.



Input File Structures

Header/Label	Details	Type	Required?
Table	Table ID	Integer	Yes
MHA	Minimum Harvest Age	Integer	Yes
OAF	Operational Adjustment Factor	Float	Yes
OAF2	Not Implemented in this version		No

I.3 Forest Inventory – *class.dat* (sample records only)

Zone	AU	LowerAge	UpperAge	Area	Class Type	ReversionAge
74	3	81	90	465.24	I	
83	3	61	70	37.89	I	
74	5	121	130	187.89	O	
74	2	81	90	1402.73	O	
84	999	51	60	60.10	I	
74	102	-5	-5	50.93	O	
73	102	-5	-5	9.12	O	

The *class.dat* file provides the forest inventory data, each record is referred to as a forest class. Each forest class and the area associated with it is defined by an age range, class type and reversion age. Area is assumed to be initially evenly distributed within the age range. The model uses one-year timber classes by generating one timber class for every year in the age range. Class type indicates whether the area is:

- (O)perable: Contributing to both Forest Cover Constraints (FCC) and harvest
- (I)noperable: Contributing to FCC only
- (D)eferred: Non-contributing to harvest, contributing to FCC
- (N)on-contributing: Non-contributing to FCC or harvest

ReversionAge is only valid for D or N types and indicates the age at which the area becomes operable. See also Section 3.1.4.



Header/Label	Details	Type	Required?
Zone	Zone identifier	Integer	Yes
AU	AU identifier	Integer	Yes
LowerAge	Lowest age in class	Integer	Yes
UpperAge	Oldest age in class	Integer	Yes
Area	Evenly distributed age	Float	Yes
Class Type	Class type	Character	No
ReversionAge	Age area becomes operable	Integer	No

I.4 Grouping – *group.dat*

Group	Type	Zone	AU	AgeLow	AgeHigh	CType
70	f	72	n/a	n/a	n/a	n/a
70	f	73	n/a	n/a	n/a	n/a
70	f	74	n/a	n/a	n/a	n/a
80	f	82	n/a	n/a	n/a	n/a
80	f	83	n/a	n/a	n/a	n/a
80	f	84	n/a	n/a	n/a	n/a
72	f	72	n/a	n/a	n/a	O
73	f	73	n/a	n/a	n/a	O
74	f	74	n/a	n/a	n/a	O
82	f	82	n/a	n/a	n/a	O
83	f	83	n/a	n/a	n/a	O
84	f	84	n/a	n/a	n/a	O

The *group.dat* file defines areas grouped together for analysis purposes. FSSIM allows two group types: (f)loat and (s)tatic. Area in a static group at the start of the planning horizon remains in that group throughout the entire planning horizon, regardless of aging, harvest, regeneration, transfers, etc. On the other hand, a float group contains area that meets the group criteria at the moment; it may change as a result of aging, harvest, regeneration, etc.

A given group can contain one or more membership criteria; however, the Type field of all criteria for a group must be the same, *i.e.* there cannot be a mix of f and s types in same group.

Ctype is Class Type as described in *class.dat*. Forest classes may be grouped for harvest targets, forest cover constraints, or other analysis purposes.



Input File Structures

Header/Label	Details	Type	Required?
Group	Group identifier	Integer	Yes
Type	(f)loat, (s)tatic	Character	Yes
Zone	Zone identifier	Integer	Yes
AU	Analysis Unit	Integer	Yes
AgeLow	Low age in group	Integer	Yes
AgeHigh	Upper age in group	Integer	Yes
CType	Class type	Character	Yes

I.5 Land Area Reduction Factors – *landoaf.dat*

Zone	AU	LandOAF
72	n/a	1
73	n/a	1
74	n/a	1
82	n/a	1
83	n/a	1
84	n/a	1

Land Operational Adjustment Factors – Land area is increased or reduced by the LandOAF. If more than one Land base OAF applies to a given area, the OAF at the lowest level in the ZONE/AU hierarchy is used. In those cases where more than one OAF at that level applies, the OAF specified later in the file is used. Any OAF contentions will be reported by FSSIM.

Header/Label	Details	Type	Required?
Zone	Zone identifier	Integer	Yes
AU	Analysis Unit	Integer	Yes
LandOAF	Land Operational Adjustment Factor	Float	Yes



I.6 Harvest and Management Targets – *targets.dat*

```

Unit Type:    ZONE
Unit ID:      0
Target Type:  VOLUME
Period        Target
1             42000.0

```

Harvest target levels can be specified for ZONE or GROUP land units (Unit Type) and as VOLUME(m³) or AREA(ha) levels (Target Type). Period indicates the first period in which the target is to apply. This target will apply for all subsequent periods in the planning horizon unless superseded.

Header/Label	Details	Type	Required?
UnitType	ZONE or GROUP	Character	Yes
UnitID	Zone# or Group#	Integer	Yes
Target Type	AREA or VOLUME	Character	Yes
Period	Period identifier	Integer	Yes
Target	Target amount	Float	Yes

I.7 Regeneration Rules – *regen.dat* (sample records only)

```

Zone  AU    PC    RAU    RDelay
72    1      100   101     4
72    2      100   102     4
72    3      100   103     4
72    4      100   104     4
72    5      100   105     4
72    6      100   106     4
72   101     100   101     4
72   102     100   102     4
72   103     100   103     4
72   104     100   104     4
72   105     100   105     4
72   106     100   106     4

```

Regeneration rules are set in *regen.dat*. The pre and post-regeneration analysis units are defined, as well as the percentage of the harvested area moving to any post-regeneration analysis unit, and the regeneration delay to be used. Regeneration percentages for a given ZONE/AU pair must add to 100.



Input File Structures

Header/Label	Details	Type	Required?
Zone	Zone Identifier	Integer	Yes
AU	Analysis Unit	Integer	Yes
PC	% Regenerated	Float	Yes
RAU	Regeneration Analysis Unit	Integer	Yes
RDelay	Regeneration Delay	Float	Yes

I.8 Forest Cover Constraints - *axs.dat*

UnitType	UnitID	Start	End	GUpAge	GUpPC	OGrAge	OGrPC
GROUP	70	1	25	40	54	100	23
GROUP	70	1	25	n/a	n/a	140	11
GROUP	80	1	25	40	54	100	23
GROUP	80	1	25	n/a	n/a	140	11
GROUP	72	1	25	28	13	n/a	n/a
GROUP	73	1	25	28	24	n/a	n/a
GROUP	74	1	25	20	33	n/a	n/a
GROUP	82	1	25	28	13	n/a	n/a
GROUP	83	1	25	28	24	n/a	n/a
GROUP	84	1	25	20	33	n/a	n/a

This file defines the forest cover constraints imposed on the analysis at either the ZONE or GROUP level. Constraints are either a maximum area depleted and under a certain age, or a minimum retention of area above a certain age. Each definition consists of the time frame (in simulation periods) in which the constraints will be applied, the age thresholds and the limits expressed as a percent.



Header/Label	Details	Type	Required?
UnitType	ZONE, GROUP	Character	Yes
UnitID	Unit Identifier	Integer	Yes
Start	Start of window in periods	Integer	Yes
End	End of window in periods	Integer	Yes
GUpAge	Green-up Age	Integer	Yes
GUpPC	Green-up %	Float	Yes
OGrAge	OldGrowth Age	Integer	Yes
OGrPC	OldGrowth %	Float	Yes

I.9 Future Roads Reductions – *roads.dat*

Zone	Age	PC
72	31	5
73	31	5
74	31	5
82	31	5
83	31	5
84	31	5

Road deductions – Area in a zone that is $\leq$ Age is assumed to have existing roads and will not be future-roaded (*i.e.* roaded as a result of harvest modelled during the planning horizon). A given timber class will not be roaded more than once during model execution.

PC specifies the percentage of harvested area to remove as road.

Header/Label	Details	Type	Required?
Zone	Zone Identifier	Integer	Yes
Age	Age in years	Integer	Yes
PC	% harvest area removed	Float	Yes



Input File Structures

I.10 Harvest Priorities – *priority.dat*

Zone	AU	Group	Period	Priority
72	n/a	n/a	1	98
73	n/a	n/a	1	99
74	n/a	n/a	1	100
82	n/a	n/a	1	98
83	n/a	n/a	1	99
84	n/a	n/a	1	100

Priorities are used to control harvest by Group, Zone or Analysis Unit. This functionality may be used to impose product requirements or operational preferences.

This example sets the highest priority to AUs 72 and 82.

Treatment Priorities – Forest classes have a default priority of 100 unless superseded by an entry in *priority.dat*.

Period specifies the first period in which the priority is to apply. This priority continues to apply for all subsequent periods throughout the planning horizon unless superseded by another entry.

The same priority can be specified more than once.

Header/Label	Details	Type	Required?
Zone	Zone Identifier	Integer	Yes
AU	Analysis Unit	Integer	Yes
Group	Group Identifier	Integer	Yes
Period	Period Identifier	Integer	Yes
Priority	1:high;100:low	Integer	Yes

Note: Priorities must be in the range of 1 to 100, inclusive: 1 = highest, 100 = lowest.



I.11 Moving Forest Classes – *transfer.dat*

```
UnitType  UnitID  Start  End  AgeLow  AgeHigh  Type ->  Zone  AU  Age  Type  RAge
AU         2      2      2      n/a      n/a      n/a      n/a  n/a n/a  N    100
```

Transfers are used to assign forest class attributes. The first seven fields before '->' specify criteria for transfer. Area meeting these criteria is transferred using the five fields after '->'. The '->' can be read as: <x> becomes <y>.

Header/Label	Details	Type	Required?
UnitType	Zone or group or AU	Character	Yes
UnitID	Zone, group or AU #	Integer	Yes
Start	Start of window in periods	Integer	Yes
End	End of window in periods	Integer	Yes
AgeLow	Low age window	Integer	Yes
AgeHigh	High age window	Integer	Yes
Type	Class type	Character	Yes
Zone	Zone ID	Integer	Yes
AU	Analysis Unit	Integer	Yes
Age	Age	Integer	Yes
Type	Class type	Character	Yes
RAge	Reversion age	Integer	Yes

Note: This is an example only. A *transfer.dat* file is not included in the sample data base.



Input File Structures

I.12 Program Execution Parameters – *param.dat*

Plan Horizon: 25
 Period Period Length Look-Ahead
 1 10 10

Basic planning horizon parameters such as the length of analysis periods and the number of periods to be modelled are contained in *param.dat*. Look-Ahead defines the time period in which the model will assess future implications of modelling activity. Period Length and Look-Ahead should be the same unless the user has good reason for them being different. E.g. setting Look-Ahead to 0 is one way of switching look-aheads off.

Header/Label	Details	Type	Required?
Plan Horizon	# of years	Integer	Yes
Period	Period Identifier	Integer	Yes
Period Length	# of years	Integer	Yes
Look-Ahead	# of years	Integer	Yes



APPENDIX II - OUTPUT FILE STRUCTURES

Figure AII.1 presents the output files organized by theme to assist in finding the appropriate file according to need.

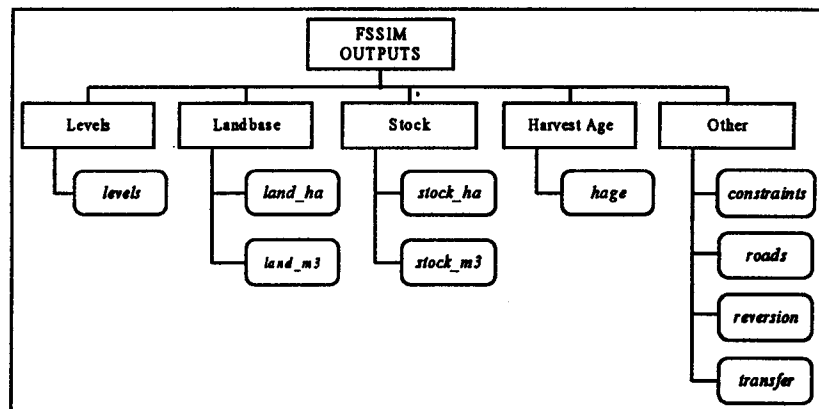


Figure AII.1 Output Files



Output Files

All reports are available for three levels: forest wide (*.rep*), by group (*.grp*), and by zone (*.zon*). Output files are listed below. These files are created automatically by FSSIM in a subdirectory named reports.

II.1	<i>levels.rep</i>	Achieved Levels (overall)
	<i>levels.zon</i>	Achieved Levels (zone)
	<i>levels.grp</i>	Achieved Levels (group)
II.2	<i>land_ha.rep</i>	Land base – area (overall)
	<i>land_ha.zon</i>	Land base – area (zone)
	<i>land_ha.grp</i>	Land base – area (group)
II.3	<i>land_m3.rep</i>	Land base – volume (overall)
	<i>land_m3.zon</i>	Land base – volumes (zone)
	<i>land_m3.grp</i>	Land base – volume (group)
II.4	<i>stock_ha.rep</i>	Growing stock – area (overall)
	<i>stock_ha.zon</i>	Growing stock – area (zone)
	<i>stock_ha.grp</i>	Growing stock – area (group)
II.5	<i>stock_m3.rep</i>	Growing stock – volume (overall)
	<i>stock_m3.zon</i>	Growing stock – volume (zone)
	<i>stock_m3.grp</i>	Growing stock – volume (group)
II.6	<i>hage.rep</i>	Harvest age (overall)
	<i>hage.zon</i>	Harvest age (zone)
	<i>hage.grp</i>	Harvest age (group)
II.7	<i>constraints.rep</i>	Forest Cover Constraints
II.8	<i>roads.rep</i>	Roads Reductions
II.9	<i>reversion.rep</i>	Class type reversions executed
II.10	<i>transfer.rep</i>	Transfers executed

Note: If the Reports option in the *config.dat* file is set to OFF, only the *levels.** files will be generated.



II.1 *levels.rep*

This file reports on simulated results for all levels.

Period	Area(ha)		Volume(m3)		Thinning(m3)		Roads(ha) Achieved
	Achieved	Target	Achieved	Target	Achieved	Target	
1	1920.54	/ -	420000.00	/ 420000.00	0.00	/ -	96.03
2	2097.25	/ -	420000.00	/ 420000.00	0.00	/ -	104.86
3	2072.15	/ -	420000.00	/ 420000.00	0.00	/ -	103.61

Period: The reporting period as entered in the data file *param.dat*

Area Achieved: The area of all levels actually achieved in hectares.

Area Target: The area of all levels that was requested in hectares.

Volume Achieved: The volume actually achieved in metres cubed.

Volume Target: The volume requested in metres cubed.

Thinning Achieved: The volume of thinning which actually occurred in metres cubed.

Thinning Target: The volume of thinning which was requested in metres cubed.

Roads Achieved: The area dedicated to future roads in hectares.

Note: Thinning is not activated in this version of FSSIM.

Similar reports are generated at the zone and group levels.



Output File Structures

II.2 *land_ha.rep*

This file reports on land base area. Note that reports are generated both before and after harvest in each period.

Landbase area report BEFORE harvest in period 1

Note: this report is generated AFTER class type reversion and transfers

Period	When	Age	Total (ha)	Operable (ha)	Inoperable (ha)	Deferred (ha)	Non-contributing (ha)
1	BEFORE	-9 - 0	192.63	174.94	17.69	0.00	0.00
1	BEFORE	1 - 10	1003.45	953.82	49.63	0.00	0.00
1	BEFORE	11 - 20	43.78	43.78	0.00	0.00	0.00
1	BEFORE	21 - 30	246.84	175.50	71.34	0.00	0.00

Landbase area report AFTER harvest in period 1

Period	When	Age	Total (ha)	Operable (ha)	Inoperable (ha)	Deferred (ha)	Non-contributing (ha)
1	AFTER	-9 - 0	729.80	729.80	0.00	0.00	0.00
1	AFTER	1 - 10	1287.34	1269.65	17.69	0.00	0.00
1	AFTER	11 - 20	1003.45	953.82	49.63	0.00	0.00
1	AFTER	21 - 30	43.78	43.78	0.00	0.00	0.00

Period: The reporting period as entered in the data file *param.dat*

When: Whether the report is before or after harvest for the period indicated.

Age: The age range of the class in years.

Total: The total area in hectares.

Operable: The area which is flagged operable (O) in hectares.

Inoperable: The area which is flagged inoperable (I) in hectares.

Deferred: The area which is flagged deferred (D) in hectares.

Non-Contributing: The area which is flagged non-contributing (N) in hectares.

Similar reports are generated at the zone and group levels.



II.3 *land_m3.rep*

This file reports on land base volume. Note that reports are generated both before and after harvest in each period.

Landbase volume report BEFORE harvest in period 1
 Note: this report is generated AFTER class type reversions and transfers

Period	When	Age	Total (m3)	Operable (m3)	Inoperable (m3)	Deferred (m3)	Non-contributing (m3)
1	BEFORE	-9 - 0	0.00	0.00	0.00	0.00	0.00
1	BEFORE	1 - 10	0.00	0.00	0.00	0.00	0.00
1	BEFORE	11 - 20	0.00	0.00	0.00	0.00	0.00
1	BEFORE	21 - 30	0.00	0.00	0.00	0.00	0.00
1	BEFORE	31 - 40	173.72	173.50	0.22	0.00	0.00

Landbase volume report AFTER harvest in period 1

Period	When	Age	Total (m3)	Operable (m3)	Inoperable (m3)	Deferred (m3)	Non-contributing (m3)
1	AFTER	-9 - 0	0.00	0.00	0.00	0.00	0.00
1	AFTER	1 - 10	0.00	0.00	0.00	0.00	0.00
1	AFTER	11 - 20	0.00	0.00	0.00	0.00	0.00
1	AFTER	21 - 30	0.00	0.00	0.00	0.00	0.00
1	AFTER	31 - 40	45.34	41.57	3.77	0.00	0.00

Period: The reporting period as entered in the data file *param.dat*

When: Whether the report is before or after harvest for the period indicated.

Age: The age range of the class in years.

Total: The total volume in metres cubed.

Operable: The volume which is flagged operable (O) in metres cubed.

Inoperable: The volume which is flagged inoperable (I) in metres cubed.

Deferred: The volume which is flagged deferred (D) in metres cubed.

Non-Contributing: The volume which is flagged non-contributing (N) in metres cubed.

Similar reports are generated at the zone and group levels.



Output File Structures

II.4 stock_ha.rep

This file reports on stocked area. Stocked area is that area which is flagged as operable in the data model. Note that reports are generated both before and after harvest in each period.

Growing stock area report BEFORE harvest in period 1

Note: this report is generated AFTER class type reversion and transfers

Period	When	Age	Total (ha)	Operable (ha)	Merchantable (ha)	Available (ha)
1	BEFORE	-9 - 0	192.63	174.94	0.00	0.00
1	BEFORE	1 - 10	1003.45	953.82	0.00	0.00
1	BEFORE	11 - 20	43.78	43.78	0.00	0.00
1	BEFORE	21 - 30	246.84	175.50	0.00	0.00
1	BEFORE	31 - 40	231.13	104.98	0.00	0.00

Growing stock area report AFTER harvest in period 1

Period	When	Age	Total (ha)	Operable (ha)	Merchantable (ha)	Available (ha)
1	AFTER	-9 - 0	729.80	729.80	0.00	0.00
1	AFTER	1 - 10	1287.34	1269.65	0.00	0.00
1	AFTER	11 - 20	1003.45	953.82	0.00	0.00
1	AFTER	21 - 30	43.78	43.78	0.00	0.00
1	AFTER	31 - 40	246.84	175.50	0.00	0.00

Period: The reporting period as entered in the data file *param.dat*

When: Whether the report is before or after harvest for the period indicated.

Age: The age range of the class in years.

Total: The total area in hectares.

Operable: The area which is flagged operable (O) in hectares.

Merchantable: The area which is flagged merchantable in hectares.

Available: The area which is available for harvesting in hectares.

Note: The Available category is not implemented in this version of FSSIM.

Similar reports are generated at the zone and group levels.



II.5 stock_m3.rep

This file reports on stocking volume. Note that reports are generated both before and after harvest in each period.

Growing stock volume report BEFORE harvest in period 1
 Note: this report is generated AFTER class type reversion and transfers

Period	When	Age	Total (m3)	Operable (m3)	Merchantable (m3)	Available (m3)
1	BEFORE	-9 - 0	0.00	0.00	0.00	0.00
1	BEFORE	1 - 10	0.00	0.00	0.00	0.00
1	BEFORE	11 - 20	0.00	0.00	0.00	0.00
1	BEFORE	21 - 30	0.00	0.00	0.00	0.00
1	BEFORE	31 - 40	173.72	173.50	0.00	0.00

Growing stock volume report AFTER harvest in period 1

Period	When	Age	Total (m3)	Operable (m3)	Merchantable (m3)	Available (m3)
1	AFTER	-9 - 0	0.00	0.00	0.00	0.00
1	AFTER	1 - 10	0.00	0.00	0.00	0.00
1	AFTER	11 - 20	0.00	0.00	0.00	0.00
1	AFTER	21 - 30	0.00	0.00	0.00	0.00
1	AFTER	31 - 40	45.34	41.57	0.00	0.00

Period: The reporting period as entered in the data file *param.dat*

When: Whether the report is before or after harvest for the period indicated.

Age: The age range of the class in years.

Total: The total volume in metres cubed.

Operable: The volume which is flagged operable (O) in metres cubed.

Merchantable: The volume which is flagged merchantable in metres cubed.

Available: The volume available in metres cubed.

Similar reports are generated at the zone and group levels.



Output File Structures

II.6 *hage.rep*

This file reports on areas by harvest age.

Harvest age (overall) report AFTER harvest in period 1			
Period	Age	Area	Volume
1	81 - 90	26.69	4412.96
1	91 - 100	22.71	4094.39
1	101 - 110	49.02	8066.90
1	111 - 120	29.93	6376.65
1	121 - 130	18.55	3484.93
1	131 - 140	252.31	50625.33
1	141 - 150	441.93	84019.93
1	151 - 160	361.17	80042.68
1	161 - 170	531.74	123076.57
1	171 - 180	62.33	19062.08
1	181 - 190	42.98	12066.30
1	191 - 200	24.35	6364.89
1	201 - 210	19.61	5255.84
1	261 - 270	33.49	11637.67
1	301 - 310	3.72	1412.88
Totals		1920.54	420000.00
Wtd Ave		154.59	157.99

Period: The reporting period as entered in the data file *param.dat*

Age: The age range of the class in years.

Area: The harvested area for the age range in hectares.

Volume: The volume for the age range in metres cubed.

Similar reports are generated at the zone and group levels.



II.7 constraints.rep

This file reports constraints which may have affected the simulation. Note that the report is grouped by period, unit type, and unit ID. The report has separate sections for before and after harvests in each period.

Access constraints report BEFORE harvest in period 1

Period	When	UnitType	UnitID	UnitArea	Age1	Disturbance		PC	Age2	Retention		PC	Violated?
						PC1	Area			PC2	Area		
1	BEFORE	GROUP	70	22108.9	40	54.0	465.7	2.1	100	23.0	9139.3	41.3	
1	BEFORE	GROUP	70	22108.9	-	-	-	-	140	11.0	2438.7	11.0	
1	BEFORE	GROUP	72	786.8	28	13.0	16.4	2.1	-	-	-	-	
1	BEFORE	GROUP	73	739.0	28	24.0	29.0	3.9	-	-	-	-	
1	BEFORE	GROUP	74	10229.1	20	33.0	184.7	1.8	-	-	-	-	
1	BEFORE	GROUP	80	25813.5	40	54.0	1229.0	4.8	100	23.0	9705.4	37.6	
1	BEFORE	GROUP	80	25813.5	-	-	-	-	140	11.0	5356.8	20.8	
1	BEFORE	GROUP	82	808.6	28	13.0	176.1	21.8	-	-	-	-	<GU>
1	BEFORE	GROUP	83	729.4	28	24.0	228.2	31.3	-	-	-	-	<GU>
1	BEFORE	GROUP	84	10821.0	20	33.0	612.7	5.7	-	-	-	-	

Access constraints report AFTER harvest in period 1

Note: generated prior to roading; roading may reduce landunit area

area reduction for roads will be reflected in before harvest report for next period

Period	When	UnitType	UnitID	UnitArea	Age1	Disturbance		PC	Age2	Retention		PC	Violated?
						PC1	Area			PC2	Area		
1	AFTER	GROUP	70	22108.9	40	54.0	1293.7	5.9	100	23.0	10820.0	48.9	
1	AFTER	GROUP	70	22108.9	-	-	-	-	140	11.0	4064.9	18.4	
1	AFTER	GROUP	72	786.8	28	13.0	102.3	13.0	-	-	-	-	
1	AFTER	GROUP	73	739.0	28	24.0	172.1	23.3	-	-	-	-	
1	AFTER	GROUP	74	10229.1	20	33.0	903.6	8.8	-	-	-	-	
1	AFTER	GROUP	80	25813.5	40	54.0	2088.9	8.1	100	23.0	13127.9	50.9	
1	AFTER	GROUP	80	25813.5	-	-	-	-	140	11.0	6072.8	23.5	
1	AFTER	GROUP	82	808.6	28	13.0	127.1	15.7	-	-	-	-	<GU>
1	AFTER	GROUP	83	729.4	28	24.0	193.0	26.5	-	-	-	-	<GU>
1	AFTER	GROUP	84	10821.0	20	33.0	1513.5	14.0	-	-	-	-	

Period: The reporting period as entered in the data file *param.dat*

When: Whether the data is before or after harvest in the period.

Unit Type: The land units may be either zones or groups.

Unit ID: This is the Identification code of the land unit.

Unit Area: The area of the land unit in hectares.

Age1, Disturbance: The green-up age specified in *axs.dat*.

PC1, Disturbance: Green-up percent specified in *axs.dat*.

Area, Disturbance: Current area below green-up.

PC, Disturbance: Current percent below green-up.



Output File Structures

Age2, Retention: Old-growth age specified in *axs.dat*.

PC2, Retention: Old-growth percent specified in *axs.dat*.

Area, Retention: Current old-growth area.

PC, Retention: Current old-growth percent.

Violated: Indicates if a constraint is violated.

II.8 roads.rep

This file reports areas made into roads. Note that reports are grouped by period, zone, Analysis Unit (AU) and group.

Area roaded in period	1
Period Zone Group AreaRoaded	
1 0 -	96.03
1 72 -	4.44
1 73 -	7.16
1 74 -	36.36
1 84 -	48.07
1 - 70	47.96
1 - 72	4.44
1 - 73	7.16
1 - 74	36.36
1 - 80	48.07
1 - 84	48.07

Period: The reporting period as entered in the data file *param.dat*

Zone: The zone represented by the data row.

AU: The Analysis Unit represented by the data row.

Area Roaded: The area in hectares which was made into roads during the period.

Note: Only future roads are reported.



II.9 reversion.rep

This file reports reversions of classes which occurred during the session.

```

Period: 1 - Class Type Reversions
Types: 1:Operable; 2:Inoperable; 3:Deferred; 4:Non-contributing
      Period Zone AU Age Area ReversionAge Type -> Type

Period: 2 - Class Type Reversions
Types: 1:Operable; 2:Inoperable; 3:Deferred; 4:Non-contributing
      Period Zone AU Age Area ReversionAge Type -> Type

Period: 3 - Class Type Reversions
Types: 1:Operable; 2:Inoperable; 3:Deferred; 4:Non-contributing
      Period Zone AU Age Area ReversionAge Type -> Type
      3 72 2 90 2.01 100 4 -> 1
      3 72 2 101 8.39 100 4 -> 1
      3 72 2 102 8.39 100 4 -> 1
      3 72 2 103 8.39 100 4 -> 1
      3 72 2 104 8.39 100 4 -> 1
      3 72 2 105 8.39 100 4 -> 1

```

Note: This is an example only. No reversions were included in the sample data set.

II.10 transfer.rep

This file reports transfers of forest classes between ZONES or GROUPs. Note that the report is grouped by period, unit type, and unit ID. The report has separate sections for before and after harvests in each period.

```

Period: 1 - Transfers
Types: 1:Operable; 2:Inoperable; 3:Deferred; 4:Non-contributing
      Period Zone AU Age Type ----> Zone AU Age Type

Period: 2 - Transfers
Types: 1:Operable; 2:Inoperable; 3:Deferred; 4:Non-contributing
      Period Zone AU Age Type ----> Zone AU Age Type
      2 72 2 71 2 ----> 72 2 71 4
      2 72 2 71 1 ----> 72 2 71 4
      2 72 2 72 2 ----> 72 2 72 4
      2 72 2 72 1 ----> 72 2 72 4

```

Note: This is an example only. No transfers were generated in the sample data set.



Output File Structures

The parameters to the left of the arrow symbol have been changed to the outputs on the right of the arrow. These changes are due to specific management regimes specified in the input files.

