Lab 3: Timber Supply Analysis

Introduction

In this lab students will produce the data files needed to use FSSIM to undertake a timber supply analysis and recommend an allowable annual cut for a study forest.

Students will be required to produce a report that describes the inventory, documents the base case forecast and sensitivity analyses, and provides a rationale for the allowable annual cut recommendation. It is recommended that students work in pairs to complete the lab and assignment. Reports may be submitted individually or by both students.

Learning Objectives

Lab 3 builds on the skills you developed in Labs 1 and 2. At the conclusion of this lab it is expected that students will understand:

- how to aggregate forest inventory into analysis units
- how to specify forest cover constraints in FSSIM
- how to prepare the data input files for FSSIM
- how to find a base case harvest forecast
- how to undertake sensitivity analysis to identify risks in data and assumptions associated with the base case
- how forest management objectives and regimes affect timber supply.

Foreword

Timber supply analysis is a sequential process, which means that many of the early decisions you make in building the FSSIM databases will affect the opportunities and outcomes of your later work. Think things through before you start, and if you need clarification, ask for help. [No one said it would be easy, but it's probably not as hard as it looks.]

You have a little more than three days to complete your analysis of timber supply for the study forest. Time will be spent roughly as follows:

- Thursday afternoon:
  - plan your analysis—specify management objectives, define indicators and criteria
  - get familiar with the forest inventory
  - determine site class boundaries, and define analysis units based on leading species and site class; think about management regimes for each analysis unit
  - using software provided, specify site class boundaries, classify the inventory into analysis units, and generate the FSSIM class file (*class.dat*).
- Friday:
  - project yield tables representing growth of existing and regenerated stands for each analysis unit, and create FSSIM yield files (*vols.dat*)
  - specify regeneration pathways for each analysis unit (*regen.dat*)
  - define FSSIM groups (*group.dat*) and specify cover constraints for each zone or group (*axs.dat*)
  - create remaining FSSIM input files (*oaf.dat, landoaf.dat, roads.dat, config.dat, param.dat*).
- Saturday:
  - develop base case harvest forecast (*targets.dat*)
  - undertake sensitivity analyses
- Monday:
  - continue sensitivity analyses
  - develop a silviculture strategy for the management unit
  - recommend an allowable annual cut
  - write and submit report

Remember, you can't hurt the computer, so don't be afraid to experiment. On the other hand, you have a limited amount of time, so use it wisely.

Good luck!

Lab 3 Overview

Lab 1 introduced you to forest estate modeling. Lab 2 introduced you to the heart of timber supply analysis—the process of establishing a base case harvest flow forecast. In Lab 3 you will process inventory files and produce the FSSIM input data files needed to undertake a timber supply analysis and recommend an allowable annual cut for a study forest.

Lab 3 in your FMIBC module 5 folder contains an inventory file (*inventory.txt*) that you will process with a program developed for this lab. This program (MODULE 5 INPUT DATA PROGRAM), will allow you to:

- browse through the inventory file (*inventory.txt*),
- define site class boundaries and run a program (SITECLASS) that assigns a site class value to each record in the inventory and generates an updated inventory file (*Updated_Inventory.txt*).
- define analysis units (in a file called *AUnit.txt*).
- run a program (CLASS) that will aggregate records in the inventory file by analysis unit, create the FSSIM *class.dat* file, and generate another file containing information needed for projecting yield tables (GY*Parameters.txt*).

You will use these programs and files to create the FSSIM input files needed to complete your timber supply analysis.

In this lab you will need to create the following FSSIM files:

class.dat	*vols.dat*	*group.dat*	*targets.dat*
landoaf.dat	*regen.dat*	*axs.dat*	*param.dat*
roads.dat	*oaf.dat*	*reports.dat*	*config.dat*

Copy your Lab 2 versions of the *.dat* files to use as templates for these files in Lab 3. First, in your Lab 3 folder, create another folder called Base Case. Put a copy of each Lab 2 *.dat* file (except the *class.dat* files) in the Base Case folder. Change the file extension from *.dat* to *.tmp*. Later, when you have modified this file by adding the new information needed for Lab 3, change the extension back to *.dat*.

Some of these input files will require no change (e.g., *param.dat*, *config.dat*). The most effort will be required to create the *vols.dat, regen.dat, group.dat,* and *axs.dat* files.

Lab 3 Assignment

You must complete the 14 steps in this lab. We strongly suggest that you document each step carefully as you work your way through the assignment. This will make it much easier to complete the report (Step 14).

Read through the full lab and make sure you understand what is required in each step before you begin.

STEP 1 Introduction to the INPUT DATA PROGRAM

The INPUT DATA PROGRAM is used to build an FSSIM *class.dat* file. Click on the start button, and under Programs, choose FMIBC, and the FMIBC Module 5 Input Data Program (IDP). This program enables you to:

- run two executable programs (CLASS, SITECLASS) by clicking on the toolbar buttons that appear when needed [**Don't run these yet.**]
- browse and edit the inventory and other files.

STEP 2 Familiarize yourself with the forest inventory

In this lab you will be working with a forest inventory derived from the TSR data set for the Fraser TSA. The FSSIM class file (*class.dat*) is generated by running the program called CLASS, which processes the *inventory.txt* file.

In the INPUT DATA PROGRAM, open the *inventory.txt* file and view the file by using the vertical and horizontal scroll bars to view rows and columns that aren't visible in the window. [**Do not edit this file**.] Each record contains information describing species composition, site index, age, crown closure, operability and area. There are blank fields in which analysis unit numbers and site class labels will be inserted by the program.

STEP 3 Specify site class boundaries for the inventory

Click on the SITECLASS toolbar button, which will open a form showing fields in which you must specify the site index class boundaries (minimum and maximum values) used to assign the site productivity classes in the inventory file. Site indexes that are between the lower boundary and the upper boundary (inclusive) will be in the specified site class.

Use the pull-down lists to choose site index boundary values. When you are finished, click on the “OK” button, which starts the SITECLASS program. SITECLASS assigns a site class to each record in the *inventory.txt* file, and creates two new files: *Updated_Inventory.txt* and *AUnit.txt*.

STEP 4 Define and assign analysis units

Define analysis units

Before you can make decisions on how to aggregate the inventory into analysis units (AUs), you need to be familiar with the species composition and site productivity of the forest. This will be easier to do if you import the *Updated_Inventory.txt* file information into an Excel spreadsheet and create a pivot table, as follows:

1 Open Excel. Under the File menu, choose Open, find the FMIBC module 5 folder [c:/windows/desktop/FMIBC module 5]. Then open the Lab 3/Inventory directory and choose *Updated_Inventory.txt*.

2 Before you can work with the inventory information you must separate the text into columns. There are approximately 26 000 inventory records in the file. Click on cell A1. Then, holding down the <Shift> key, press <End> and then <down-arrow>, which selects the entire column with data in it. Choose Data/Text to Columns and use the Excel “wizard” that starts up to convert the text file to columns in the spreadsheet.

3 To create a pivot table, first select the entire table of numbers. (Place the cursor in cell A1, and holding down the shift key, use the right arrow key to select the first row of numbers, then touch the end key and the arrow down key.) Under the Data menu, select Pivot Table and Pivot Chart Report. Click Next two times, choose New Worksheet, and then click Finish.

   Now, design your pivot table. Drag species1 and species2 to the row section of the table, site class to the column section, and area to the data section (where it will show as “sum of area”). All going well, you will have created a table that summarizes the inventory records by leading and secondary species and site class. This table will be useful in making decisions about analysis units. [**Save this worksheet as an Excel file (*updated_inventory.xls*) and print a copy**.]

When thinking about how to define AUs, remember that you will have to create two volume tables for each AU. Not all species are included explicitly in TIPSY—some will be used as surrogates for others. Consider the amount of area in each species combination and site class.

Assign analysis units

Return to the INPUT DATA PROGRAM, and open the file *AUnit.txt*. It lists every combination of leading and secondary species, site class, and class type (operability) for the inventory. Depending on the site class boundaries you chose, there may be a little more than 200 records in this file.

Once you have decided on the composition of your AUs (species composition and site class) assign an AU number in the first column of the *AUnit.txt* file. Save the file when done.

STEP 5 Use CLASS to process inventory files into analysis units

Run the program CLASS by clicking on the button labeled <CLASS>. This program creates three files: *Inventory_Summary.txt*, *GYParameters.txt*, and *class.dat*.

Open and inspect the file called *Inventory_Summary.txt*. Each record in this file is an aggregate of inventory records (from *Updated_Inventory.txt*) having the same combination of zone, species 1, species 2, site class and class type (OPER). That is, the file will be an inventory file with area aggregated according to the analysis units defined in *AUnit.txt*. Check to verify that the classes have been aggregated as you expected. If not, check the *AUnit.txt* and *Updated_Inventory.txt* files to confirm that they are properly specified.

The file called *GYParameters.txt* contains weighted average site index, crown closure, and species composition values that will be needed to project yield curves for each analysis unit.

The third file created by CLASS, called *class.dat*, is the inventory file used by FSSIM.

STEP 6 Create volume tables for each analysis unit

Define a management regime for each AU (how it will be regenerated, initial density, will it be thinned, etc.). **Specify no regeneration delay in TIPSY**. Create volume tables representing the development of natural stands using VDYP, and the development of managed stands using TIPSY. The parameters needed to run these yield models can be found in the file called *GYParameters.txt*. Use the weighted SI for the AU and enter the % of each species (must total 100%).

Note that any yield model or yield table can be used to develop the volume tables needed to run FSSIM. In this course we use VDYP and TIPSY because they are convenient and widely accepted for use in BC.

Creating the *vols.dat* file is onerous, especially if you have specified a large number of AUs. You can take different approaches to creating this file. One is to print the VDYP or TIPSY volume tables that you created, and then type the age and volume information directly into the *vols.dat* file. A second approach is to copy the TIPSY and VDYP output, paste it into Excel, reformat the information, and then save it as a space-delimited text file (*.prn*).

These approaches take about the same amount of time.

If you choose the second approach, follow these steps:

1 Copy the VDYP or TIPSY volume table into a new Excel workbook. It will copy into the first column of the spreadsheet. Select the column of pasted information. Under the Data menu, select Text to Columns, and follow the Wizard through the default steps to separate the information into columns. You need only two columns of data for your *vols.dat* file—age, and volume. Delete the columns you do not need. **Somewhere in your notes, record the CMAI for the table**.

2 Insert two rows above the table (as shown below), and insert a Table identifier (Table: <table #>), and column headers (Age, Volume). There should be no space between the header rows and the first row of data.

```
Table:   1
 Age     Volume
  10       0
  20      20
  etc….
```

3 Following this procedure, create all the volume tables needed, adding each new table below the one just created. Leave one blank row between the bottom of one table and the top of the next. When you have created all the volume tables needed, with header rows for each table, centre the columns and adjust the column widths so that there is some space on each side of the entry in each cell. Doing this will ensure that the text file (*vols.dat*) is properly spaced.

Save the file as an Excel file with name *vols.xls* to archive it in Excel in case you have to come back to modify it.

Next, save the file again, this time in the format needed for FSSIM. Choose **Save As…** under the File menu. Specify the File name as *vols.dat* and the file type as "Formatted Text (Space delimited)(*.prn)". Finally, in Windows Explorer change the name of the file to *vols.dat.*

STEP 7 Define regeneration pathways

The *regen.dat* file charts the post-harvest regeneration path for each analysis unit. Open the *regen.tmp* file and type in the regeneration analysis unit (RegenAU) assigned to each AU after harvesting. Type the associated regeneration delay as the negative regeneration age in the RegenAge column. [Which is why we warned you to specify no regeneration delay in TIPSY.] Note that you can specify portions of an analysis unit to go to different RegenAUs under the PC [percent] column. You must enter the pathway for each analysis unit in each of the seven zones in the TSA. [Poor people who have very many AUs!!]. When you have finished, save the file as *regen.dat*.

STEP 8 Define minimum harvestable age

Choose the criteria by which you will define minimum harvestable age: culmination of MAI, age when some minimum average diameter is reached, age when some minimum volume is reached, or some other criterion. [**Write it down**.] Apply this criterion consistently when setting a MHA for each analysis unit in the *oaf.tmp* file. Specify OAF1 as 1.0 and OAF2 as 0.0 for each AU. When complete, save this file as *oaf.dat*.

STEP 9 Define management objectives and requirements, and construct FSSIM data files needed to represent these objectives and requirements

One way to represent special management emphasis is by applying forest cover constraints. Applying a cover constraint requires first identifying the unit to which the constraint will be applied, and then constructing a constraint in the *axs.dat* file.

In your data set, Fraser TSA landscape units have been aggregated into seven FSSIM zones. Management emphasis areas will be represented in the model as groups composed of these zones (Table 1). Cover constraints representing management emphasis for non-timber values will be assigned to these groups. The parameters for each management emphasis are shown in Tables 2-4.

Open the file called *group.tmp,* and create a group that will represent each management emphasis area. When done, save this file as *group.dat*.

Next, in file *axs.tmp,* create a forest cover constraint representing each management emphasis (Tables 2 to 4) in the appropriate groups. When done, save this file as *axs.dat*.

Table 1 Zones in each management emphasis area.

Management Emphasis Area	Zone
Retention VQO	1
Partial Modification VQO	2, 3, 6
IRM	4, 5, 7
Spotted Owl SRMZ	1, 2
Biodiversity—NDT2	1, 4, 5, 6, 7
Biodiversity—NDT3	2, 3

Table 2 Visual quality objectives (VQO), by zone.

Zone	Area (ha)	VQ0	Green-up age (year)	Maximum Disturbed Area (%)
1	16921	R	16	3
2	51437	PM	16	15

3	58322	PM	16	15
4	65634	IRM	12	30
5	99814	IRM	12	30
6	90534	PM	16	15
7	114641	IRM	12	30

Table 3 Natural Disturbance Type (NDT) and old-growth constraints, by zone.

Zone	NDT	Old-growth age	Old-growth % requirement, by decade		
		(years)	1-70	71-140	141+
1	NDT2	250	7	8	9
2	NDT3	140	11	13	15
3	NDT3	140	11	13	15
4	NDT2	250	7	8	9
5	NDT2	250	7	8	9
6	NDT2	250	7	8	9
7	NDT2	250	7	8	9

Table 4 Spotted owl management emphasis and cover constraints, by zone.

Zone	Age limit (years)	Minimum area (%)
1	100	67
2	100	67

Create groups for reporting

You may also wish to create groups that identify specific components of the landbase (e.g., FSSIM zone) or inventory (e.g., a particular analysis unit or a range of age classes) so you can report on their condition (e.g., you might want to view the seral stage distribution for the whole forest or within each zone). Create a group in *group.dat* for each such component.

Each group must be added to the *reports.dat* file if you want the results to be reported in the FSSIM tabular reports and the group to be visible in the FSSIM Graph Results window.

STEP 10 Specify remaining FSSIM input files

Before running FSSIM, you must also create *param.dat, config.dat, landoaf.dat* and *roads.dat* files. Open the *.tmp* versions of these files and complete as necessary, then save each file as a *.dat* file.

In the roads.dat file, specify a deduction of 1% to be applied to stands older than 120 years.

STEP 11 Use FSSIM to produce a base case harvest forecast

The base case is the best harvest forecast you can produce, based on current management practices. It should ensure the long-term productivity of forest lands, while avoiding excessive changes from decade to decade and future shortfalls. The base case provides a basis for comparison when assessing uncertainty about, or changes to, data and assumptions.

The base case harvest forecast you developed in Lab 2 was for a very simple representation of this forest (e.g., 5 analysis units, no forest cover constraints). To develop a new base case harvest forecast, follow the same steps: find the maximum LTHL, set the initial harvest level, and define the transitional harvest level. Keep in mind that the decisions you make in each of these steps may make it necessary to reconsider and adjust the previous steps. Target harvest levels are set in the *targets.dat* file.

1 *Find the maximum LTHL*: The LTHL is the maximum harvest level that can be supported by an entirely second-growth forest. A simple and quick approach to finding LTHL is to use LRSY as a first estimate. Calculate LRSY using the AUs and volume tables you developed in the previous steps. Note that the areas shown in the *GYParameters.txt* file include only hectares that are older than 30 years. To find the areas needed for calculating LRSY, create a pivot table of the *Inventory_Summary.txt* file.

2 *Set the initial harvest level*: Find an initial harvest level that is the maximum that can be cut without causing the harvest in later periods to drop much below the LTHL.

3 *Define the transitional harvest level*: Find an acceptable transitional flow from initial harvest level to LTHL. There are many possible combinations of initial and transitional harvest levels, so you should decide early on what "acceptable" means. [**Write it down**.] For example, you might choose to maximize the first-decade harvest, subject to the following requirements:

   – the drop in harvest level between periods must not exceed some specified %

   – the target harvest level must be met in every period

   – growing stock inventory must not be declining at the end of the planning horizon

   – growing stock inventory must never be less than some absolute amount.

   Your definition of an acceptable transitional flow defines the harvest flow policy for your analysis. Keep in mind that your choice of flow policy may require changing the initial harvest level.

Run FSSIM and investigate the graphs and reports to evaluate each run. Adjust your harvest levels and repeat the process. Continue with this cycle of simulate-evaluate-adjust targets until you feel that you have found an appropriate or acceptable base case harvest forecast. **Record your runs and findings in the attached Table 4-1.**

STEP 12 Use FSSIM to undertake sensitivity analysis to assess risk and uncertainty associated with the data

Sensitivity analysis is done to determine the sensitivity of forest performance to changes in the value of the parameter and thereby determine the significance of uncertainty about the value of that parameter. The changes are always relative to the base case and, therefore, can only be done after the base case has been established.

In general, sensitivity analysis involves first changing the value of a model parameter (e.g., minimum harvestable age), and then measuring the effect of that change on forest performance (e.g., maximum sustainable harvest).

Making the change in the parameter being tested is straightforward—you simply change its value—but measuring the effect of that change can be more difficult.

Measuring the effect on forest performance

Measuring forest performance is difficult to do with timber supply simulation models because the quality of the outcome of a run is evaluated subjectively. FSSIM provides several indicators of the state of the forest in each period. Many can be used as measures of forest performance: growing stock inventory, age class distribution in each period, mean harvest age, harvest-age distribution, mean volume per hectare harvested, and area harvested.

Before beginning the sensitivity analysis, decide which criteria you will use to measure forest performance [**Write these down**].

The following table indicates some examples of issues that can be tested with sensitivity analysis. You should do at least the first two on the list. Use Table 4-1 to record your sensitivity analysis runs. Be sure to record the values you are testing in the assumptions column. **Use Table 4-2 to record the issues you test and their sensitivities.**

Issue to be tested	Sensitivity levels	Data source
Minimum harvestable age	reduce minimum volume requirement or age	Recent timber sale licences (experimental)
Green-up height	- 1 m	
Regenerated stand yields	+ 25%	Class A seed
Existing stand yields	+ 12%	recent inventory audit
Age when forest achieves “old” forest characteristics	Reduce from 140 to 100 years	Radio-collar study in caribou and deer show use of stands with these attributes
Site index estimate for older stands	Adjust SI by equation provided by Research Branch	Recent OGSI paired plot initiative
Landbase changes		
Harvest flow alternatives	rate of change between periods	

When adjusting the values of a parameter (for sensitivity analysis or when making a series of runs to determine the maximum long-term harvest level), change only one thing at a time. If you change the value of more than one parameter before a run, you won't be able to tell which of the parameters caused the change in model results.

STEP 13 Suggest a silviculture strategy and recommend an allowable annual cut for the study area

Based on your analysis, can you suggest an appropriate silviculture strategy for this management unit? Recommend an AAC for the next 5-year period.

STEP 14 Produce and submit your analysis report

Your report should describe the inventory, document the base case forecast and sensitivity analyses, and provide a rationale for the allowable annual cut recommendation. Attach your tables 4-1 timber supply analysis recording sheets and 4-2 issues and sensitivity analyses.

Table 4-1 Timber supply analysis recording sheet.

Run #	**Assumptions** (e.g., base, sensitivity to yield, treatment response, harvest rule)	**Harvest target (000 m^3/yr)**						**P1 growing stock**	**Minimum growing stock**		**Comments**
		P1	P2	P3	P4	P5	LTHL	(million m^3)	(million m^3)	Period	

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		P1	P2	P3	P4	P5	LTHL	(million m^3)	(million m^3)	Period	

Table 4-2 Issues and sensitivity analyses.

Issue to be tested	Sensitivity levels	Findings