Forest Resources Planning - Silviculture Module Software Program

FRDA WP-6-016
FERIC Special Report No. SR-110

Working Paper

CANADA~BRITISH COLUMBIA PARTNERSHIP AGREEMENT ON FOREST RESOURCE DEVELOPMENT: FRDA II

Canada

BC

Forest Resources Planning - Silviculture Module Software Program

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FERIC Special Report No. SR-110

by

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This report was prepared as part of the Economics and Social Analysis Program of the Canada–British Columbia Partnership Agreement on Forest Resource Development: FRDA II.

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June, 1996

ABSTRACT

FERIC developed the Forest Resources Planning (FRP) computer program to help forest planners with area-based harvesting and silviculture planning. Working in conjunction with the TerraSoft GIS, FRP allows planners to designate roads and cutblocks on digital maps, and to calculate various costs, revenues, and volumes. FRP's Silviculture Module enables the user to estimate silviculture costs and forecast the forest's development on a treatment-unit basis. A GIS-based system for classifying biogeoclimatic site-series polygons was developed. The objectives, structure, and role for FRP are described.

AUTHOR

Jack MacDonald is a Senior Researcher in the Harvesting Operations Group of FERIC's Western Division. He graduated from the University of British Columbia in 1976 with a Bachelor of Science in Forestry (Harvesting) and is a Registered Professional Forester in British Columbia. Jack worked as a forest engineer on coastal British Columbia until he joined FERIC in 1986. He worked on harvesting system evaluations, but has specialized in GIS applications and harvesting-planning software design since 1990.

Jack was the project leader and primary programmer for both the FRP Harvest Module and the Silviculture Module.

ACKNOWLEDGEMENTS

This project was supported by the Canadian Forest Service through the Economic and Social Analysis Program of the Canada–British Columbia Forest Resources Development Agreement (FRDA II).

Warren Huestis, a co-op student from Simon Fraser University, did much of the original programming for the FRP Harvest Module. Andrew Faulkner helped with the Silviculture Module's initial development. He designed the basic three-way division of data in the FRP Silviculture Module. Andrew Mitchell, British Columbia Ministry of Forests, provided significant input and feedback on the design of both modules.

DISCLAIMER

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EXECUTIVE SUMMARY

This is an extended summary for readers who may not wish to peruse the complete report. References are made to Figures and Tables in the body of the report.

Introduction

Between 1990 and 1992, the Forest Engineering Research Institute of Canada (FERIC) developed software to assist in area-based harvest planning using a personal computer. This software, Forest Resources Planning–Harvest Module (FRP-HM), provides a data structure for basic harvest planning, and includes attributes such as timber volume, species distribution, log grades, harvesting equipment, road costs, and harvesting dates. Using FRP-HM, the planner can designate cutblock locations, harvesting systems, and proposed harvesting dates, and then make volume, revenue, and cost projections based on the proposed harvesting plan. The database structures can be modified by the user in order to customize FRP-HM for specific requirements at different locations.

However, the software was incapable of forecasting the forest development that would result from implementing the harvesting and silvicultural plan, or of calculating the costs of the silvicultural activities. The objective of this project was to develop software that would provide FERIC's existing program with the capability to:

1. Implement methods for planning all silvicultural activities for each site.
2. Implement a computer model for estimating the costs of silvicultural treatments on a site-specific basis.
3. Implement a method for classifying the forest into unique areas that incorporate both site growth potential and proposed harvesting schedules. The basic land unit would be derived from a GIS overlay of the biogeoclimatic classification and the proposed harvesting plan.
4. Implement a computer model for forecasting forest development.

Model Description

The software program, Forest Resources Planning (FRP), consists of harvest and silviculture modules, both of which can be linked with a Geographical Information System (GIS). The programs were written in the FoxPro database management system and the TerraSoft GIS, and run on IBM-compatible personal computers under the MS-DOS operating system.

FRP-HM was designed for planning the harvest on tracts of land 5 000 to 20 000 ha in size. Each operating area is analyzed as a separate FRP-HM project, and is further subdivided into development units and cutblocks (Figure 1). Using FRP-HM, the planner could designate the harvesting systems, harvesting dates, and other information for each cutblock, and then generate various tabular and graphical reports (Table 8).

The silviculture module (FRP-SM) allows the planner to subdivide each cutblock into treatment units (Figure 3) for scheduling silvicultural activities and forecasting growth. The activities for each site are assigned according to various silvicultural prescriptions (Table 4), and are costed depending on various site-difficulty factors (Table 5). FRP-SM makes use of silvicultural regimes in order to apply different silvicultural prescriptions to similar sites.

Recognizing that the forest changes with time, FRP-SM allows the planner to focus on specific forest-development attributes for modelling, and project their values at various points in time. The results of the forecast, or *scenario*, could be reported in tabular or graphical format (Figure 4, Figure 5), or they could be exported to additional software for further analysis and formatting.

As well as linking with timber-based models, FRP-SM provides an open framework in which any age-based models can be used to predict the levels of non-timber parameters such as hydrologic recovery or habitat suitability index. FRP-SM provides the user with the ability to display the results of these models on colour-themed GIS maps.

A GIS-based method for classifying the site according to the British Columbia Ministry of Forest's "Field Guide for Site Identification and Interpretation" has been developed using TerraSoft GIS. This classification method allows the planner to delineate treatment units based on site and topographic information.

Discussion and Conclusions

FRP can be used for planning harvest and silvicultural activities in a GIS-based environment. The software provides the data structures and theme definitions for TerraSoft GIS so that the planner can start with a working solution instead of creating the structures from scratch. Various tabular reports and colour-themed maps can be generated, showing the forest development that will result after implementing the harvesting plan. The linkage to GIS maps is not limited to specific yield models; instead, FRP-SM provides the planner with a framework in which models from different sources can be included in the analysis and attached to GIS maps.

Alternative approaches to harvest planning include using simulation software to determine the best harvesting schedule. These programs automatically perform some of the functions that are done manually in FRP; however, they also presume that a GIS database of cutblocks and roads already exists. The databases generated by FRP can supply these inputs to the scheduling programs.

INTRODUCTION

Background

The task of scheduling timber harvesting becomes more difficult as both legislation and public input increase. The forest planner is faced with the task of balancing multiple, and often contradictory, land-use requirements on a specific tract of land.

In British Columbia, the introduction of the Forest Practices Code[1] has increased interest in the area of harvest planning because a new level called the Forest Development Plan has been added to the list of required approvals. The Forest Development Plans must demonstrate that timber harvesting will not have a negative impact on other resources such as hydrologic, wildlife, and visual values.

To help manage the complexity of planning for timber harvesting and to ensure compliance with the regulations, forest managers are adopting the concept of area-based planning and are seeking computer-based software solutions to help with the task. The Forest Engineering Research Institute of Canada (FERIC) has long supported the concept of area-based planning, and has published handbooks (Breadon 1983, 1990) and conducted workshops (Anonymous 1990) on the subject. FERIC has also produced software for planning and managing timber harvest within geographical units such as watersheds (MacDonald 1993). The existing software works in conjunction with a geographical information system (GIS) for inputting and displaying data, and for performing spatial analysis. As FERIC's existing software displayed only current forest inventories, with no provision to forecast forest development, its utility was limited with respect to the Forest Practices Code.

With funding from the Canadian Forest Service under the Canada–British Columbia Forest Resource Development Agreement (FRDA II), FERIC began development of extensions to the existing software in 1993 to address these deficiencies. The new software would assist in forecasting the changes to the forest resulting from timber harvesting and silvicultural treatments and would calculate the estimated costs of the silvicultural treatments.

This report will describe the scope of the software and discuss the software's role in forest planning.

Objectives

The project's objectives were to:

- Develop software integrated with the existing harvest-planning program to forecast the forest development and to estimate the cost of various silvicultural activities, and
- Demonstrate the software, make it available for use, and provide some training support.

FERIC's existing software was entitled Forest Resources Planning–Harvest Module, or FRP-HM, and the new software is entitled Forest Resources Planning–Silviculture Module or FRP-SM.

[1] The Forest Practices Code provides a legislative framework for the sustained use of British Columbia's forest resources using principles of respect for future needs, stewardship, balanced use, conservation, and restoration of damaged ecologies (British Columbia Ministry of Forests 1994). It is the legislative basis for planning all forest practices on Crown land in British Columbia.

Together, these two modules are called Forest Resources Planning, or FRP. The project was intended to provide the existing software with four new capabilities:

1. Implement methods for planning all silvicultural activities for each site.
2. Implement a computer model for estimating the costs of silvicultural treatments on a site-specific basis.
3. Implement a method for classifying the forest into unique areas that incorporate both site growth potential and proposed harvesting schedules. The basic land unit would be derived from a GIS overlay of the biogeoclimatic classification and the proposed harvesting plan.
4. Implement a computer model for forecasting forest development.

The new software would retain the basic operating principles and scope of the existing software; that is, it would run on personal computers and be able to link to GIS that support xBase attribute files. For users without a compatible GIS, the software could continue to be used in a stand-alone mode, albeit with reduced capability.

FRP was designed as a tool for forecasting the costs and results of implementing harvesting and silvicultural plans; it was not intended as a replacement for silvicultural record-keeping systems, which are used by the forest industry to meet various regulatory reporting requirements.

METHODS

Prior to commencing development work with FRP-SM, FERIC demonstrated the existing FRP-HM to member companies and described the proposed enhancements for FRP-SM.

The programming languages for FRP-SM were determined by the previous history with FRP-HM which was an MS-DOS–based system. The TerraSoft GIS was selected for FRP-HM because it was used by the harvesting planners of the British Columbia Ministry of Forests (BCMOF); the BCMOF sponsored the development of FRP-HM. The FoxPro database language was selected for the original software development because it was compatible with the xBase file format used by TerraSoft, it had a compiler, and it provided good performance on personal computers.

FRP-SM provides an open framework for modelling in which almost any model can be linked to a GIS map. The testing was done with data from the BCMOF VDYP (Smith 1991) and Tipsy (Mitchell et al. 1992) yield models[2] (see Glossary), although any model that describes attributes changing in value as a function of age could have been selected.

MODEL DESCRIPTION

Planning Philosophy, Scope, and Limitations

As an extension to FRP-HM, the new software continues to use the same planning philosophy. FRP-HM was designed for planning the harvest on a specific tract of land such as a watershed; the size of typical operating areas would be 5 000 to 20 000 ha. For large-scale planning problems

[2] The use of the BCMOF yield models should not be interpreted as an endorsement for any specific purpose. They are used only as examples of the type of models that can be managed and linked with GIS maps using FRP-SM.

such as entire Tree Farm Licences, the area would be divided into smaller units for individual analysis. For the harvesting analysis within each operating area, each cutblock would be identified and digitized, and for the silvicultural analysis, cutblocks would be further subdivided into treatment units.

The software was not intended as an expert system that would automatically make the planning decisions. Instead, it was envisioned that the forest planner would develop a harvesting plan using FRP-HM, and would know what silvicultural treatments to apply on each site. Using the combined FRP-HM and FRP-SM, the planner could designate the harvesting systems, harvesting dates, and other information for each cutblock, and then designate the post-harvesting silvicultural treatments. Costs for all activities could be estimated and reported.

FRP-SM also provides a method for predicting the future condition of the forest, and displaying it on a GIS map. FRP-SM allows the planner to decide which forest-development attributes are of interest for modelling, for example, conventional timber-based attributes such as height or volume, or non-timber attributes such as habitat suitability index or visual quality index. The growth models used in FRP-SM are all pre-defined and derived from external sources. The attribute values must be expressed as a function of age, and each growth model is associated with performing a specific set of silvicultural activities on a specific site type.

The results of the forecast could be reported in tabular or graphical format, or they could be exported to additional software for further analysis and formatting.

The Biogeoclimatic Ecosystem Classification (BEC) system was derived from the BCMOF Land Management Handbook Number 23 "A Guide to Site Identification and Interpretation for the Kamloops Forest Region" (Lloyd et al. 1990). The framework may be applicable to other regions, but the specific classifications included with FRP-SM are limited to the Kamloops Forest Region.

Furthermore, the classification system was written with the TerraSoft GIS and is limited by the functions of that GIS. In particular, the classification system uses a grid-based approach, so the polygon boundaries generated by the system follow the grid boundaries. Because there is no method for removing "noise" or anomalous grid cells, the BEC themes include many small polygons that may be insignificant under practical conditions.

Companion Software and Hardware Requirements

FRP is an MS-DOS–based system that runs on IBM-compatible personal computers with a minimum recommended 486-33 MHz processor and 5 MB of available disk space. FRP is distributed as a compiled FoxPro program together with the FoxPro runtime libraries; therefore, it does not require a separate database program to operate. If desired, the results of FRP-SM calculations can be further manipulated with standard programs such as spreadsheets or business graphics programs.

FRP was designed for use with a GIS,[3] for inputting, creating, and displaying data. The GIS must be capable of using attribute information stored in xBase-format files. However, many of the FRP

[3] The linkage between the GIS and FRP is by way of the database tables; FRP can be used with GIS other than TerraSoft provided they can produce the required database tables. Several GIS commonly support xBase attribute database tables. However, there are two areas where some specific tools were developed for use with TerraSoft GIS. (1) The database table for the overlay between the cutblock polygons and the forest cover-polygons is produced automatically with the TOPO program in TerraSoft; this function could be duplicated easily in most GIS. (2) The biogeoclimatic classification and treatment-unit database table is produced with TOPO using some fairly involved procedures. It would be time-consuming to reproduce these functions with another GIS.

functions can be used independent of a GIS, for example, volume, value, and cost calculations; growth modelling; and tabular reports. Without a GIS, it is necessary to import the database files from another application such as a spreadsheet, or to enter the data via the built-in editing screens.

The GIS must supply a database of the treatment units to FRP-SM before the analysis can be undertaken. FRP-SM was designed to integrate with Forest Resources Planning–Harvest Module, and it is presumed that a harvesting plan exists in FRP-HM. If the harvesting plan does not exist, then the planner must create the treatment unit database manually.

In addition to storage requirements for FRP and the GIS, 5 to 30 MB of disk space are required for each project, depending on the size of the study area and the specific GIS.

Data Organization Overview

The data that comprise FRP-SM are organized in three groups:

- Georeferenced data supplied by the GIS that are specific to one project.
- Models that will be used for costing and growth forecasting and that apply to all FRP-SM projects.
- Forecasted scenario results that are specific to one project and that can be used by the GIS.

Some of the georeferenced data are used by both FRP-HM and FRP-SM, but the models and scenario results are used only by FRP-SM.

Georeferenced Data from the GIS

All georeferenced data within FRP are organized in a hierarchy (Figure 1). The first three categories are required for FRP-HM, and the last category is used by FRP-SM. Some of the data for FRP-SM are derived from FRP-HM. The four levels of area designations within FRP are:

- Forest: The forest contains information about the entire project, and each project consists of exactly one forest. A forest is a distinct geographical entity such as a watershed, and typically occupies from 5 000 to 20 000 ha. The performance of FRP on current PCs for areas larger than 20 000 ha would be unsatisfactory.[4]
- Development unit: A forest may contain any number of development units, and each development unit typically represents the area developed by a secondary road.
- Cutblock: A cutblock is an area with uniform harvesting characteristics, i.e., it must be harvested with one system and for one scheduled harvest date.
- Treatment unit: A cutblock may contain any number of treatment units. Each treatment unit will be scheduled for one silvicultural prescription and will be assigned to one set of curves for growth modelling.

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[4] Performance is a function of the computer hardware, number of treatment units, and the complexity of the models. For example, the processing times on a Pentium 75 MHz computer for a 6 200 ha area with 2 500 treatment units were approximately 40 seconds for scenario values for two parameters, and 45 seconds for silvicultural costs for three activities.

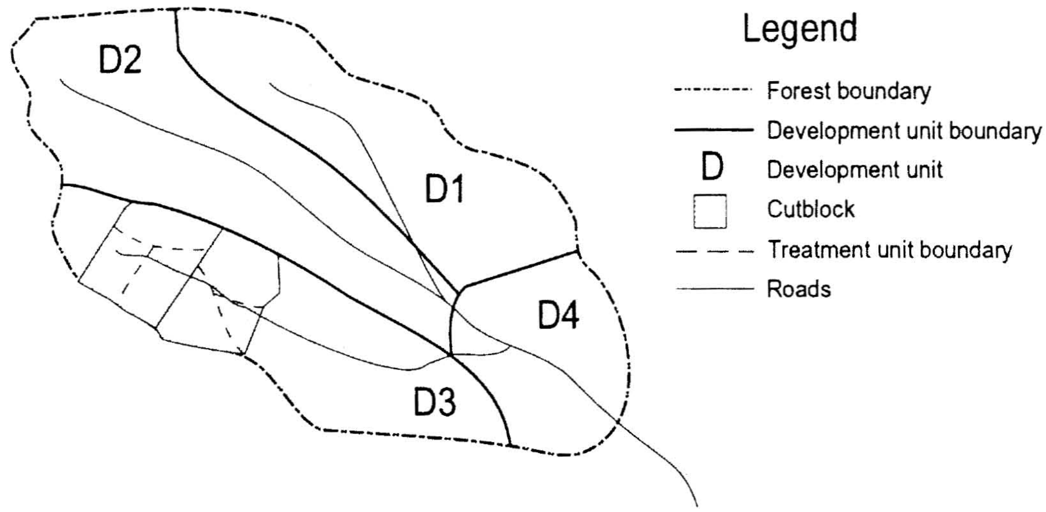

Figure 1. Georeferenced data organization in FRP.

The cutblocks and treatment units are the fundamental units for recording the harvesting and silvicultural activities and comprise the primary databases in FRP. The forest and development units are used primarily for the costing and reporting functions.

For harvest planning, FRP-HM also supports the use of a road-network database for scheduling road construction and estimating road costs.

FRP-SM Models

FRP-SM provides modelling in four areas: biogeoclimatic classification, prescription classification, growth modelling, and costing. The models apply to all projects analyzed with FRP-SM, as opposed to the georeferenced data which apply to one project only.

Biogeoclimatic classification: The model uses topographic, soils, and forest-cover information to derive the soil moisture and soil nutrient regimes, from which it derives the biogeoclimatic site series classification. The classification system was written using the TerraSoft GIS and is not portable to other GIS.

Prescription classification: In this system, biogeoclimatic site series are classified into groups with the same silvicultural prescriptions. Using TerraSoft GIS, treatment-unit polygons are generated by combining the prescription classifications and the cutblock boundaries. Without the TerraSoft GIS classification systems, the user could digitize biogeoclimatic site series and prescription polygons manually. Standard GIS techniques could be used to generate treatment unit polygons with overlays.

Growth model: A set of curves is assigned to each treatment unit to represent the growth functions for the combination of biogeoclimatic site series and silvicultural prescription. FRP does not define its own growth models; instead, it provides a method for linking external models with the GIS framework. The model content is not restricted by FRP; the models may include any attribute of interest to the planner. They are derived from any model capable of generating a table of age-related values.

Costs for silvicultural activities: Each silvicultural prescription is comprised of a list of activities. FRP will calculate the cost of each activity, as influenced by site-specific difficulty factors as explained later.

Forecasted Scenario Results

The modelling in FRP-SM allows the planner to predict the forest development for each treatment unit for a specific harvesting plan and silvicultural plan, and to estimate the costs of implementing the plans. FRP stores its forecasted results as independent *scenarios* for subsequent analysis. Running a scenario in FRP creates a new database table that is linked one-to-one with the treatment unit database table so that the modelling results appear as attributes of the treatment units. The results can be reported in tabular format or can be linked to the treatment unit polygons in the GIS for queries and display.

For each treatment unit, FRP-SM calculates the cost of the individual silvicultural treatments and then summarizes them by cutblock. The individual activities are tagged with their scheduled date so that reports can be filtered to include activities within a specified time period.

The silvicultural treatment cost estimates are combined with the harvesting cost estimates from FRP-HM to be included in the FRP standard reports. As well, the end-user can customize existing reports and create new reports by way of the FoxPro report writer included with FRP.

The growth modelling results are stored in the same database tables as the silvicultural cost estimates for each scenario. As with the cost estimates, the forecasted values can be printed in reports using the FoxPro report writer. To display the results in the GIS, the polygons from the treatment-unit theme must be associated with the scenario database table. This capability is inherent in the TerraSoft GIS; other GIS have similar capabilities. Colour-themed maps can be created with the GIS to display the estimates of the various parameters for different points in time, for example, the estimated crown closure in the year 2020.

Since FRP-SM allows the planner to define and change parameters, the exact structure of the scenario database tables cannot be fixed permanently. However, the structure is predictable: the database table will contain a new field for each combination of parameter and forecast date. The name of the database field will be determined by the scenario definition, as described below.

USING FRP

One of the key features of FRP is its ability to integrate the GIS with customized application software. As a first step, FRP-HM creates various database tables that are populated using the GIS. FERIC has written a program for TerraSoft GIS to aid the planner in creating and populating the cutblock and treatment unit database tables. This program, referred to as TOPO, is specific to TerraSoft GIS but its functions could be reproduced for other GIS.

Once the database tables have been created and populated, the next step is to forecast the costs and growth using FRP-HM or FRP-SM, independent of the GIS. Finally, the results of the analysis can be displayed in tabular or graphical format.

FRP-HM

The cutblocks and harvesting information must be entered completely into FRP-HM before commencing with FRP-SM. FRP-HM is used to set up the required database tables and then the required TerraSoft themes are processed with TOPO.

The starting point for an FRP-HM project is a spatial database of forest-cover polygons, cutblocks, and road network (Figure 2). In this example, the forest-cover linework was imported from the B.C. Ministry of Forest inventory map and the cutblocks and road network were digitized manually from a paper map. The TerraSoft themes were all processed with TOPO.

The GIS maps such as Figure 2 were generated by the TerraSoft plot module, and are indicative of analytic-quality maps. TerraSoft can produce presentation-quality maps with additional work.

Each cutblock is associated with a record in a database table (Table 1) for storing information about harvesting systems, scheduled harvesting date, timber volumes, costs, non-timber resources, etc. Maps can be coloured with the cutblocks shaded according to any of the attributes in the database table. In Figure 2, the cutblocks are shaded according to their year of scheduled harvest; this information was entered into the database using FRP-HM.

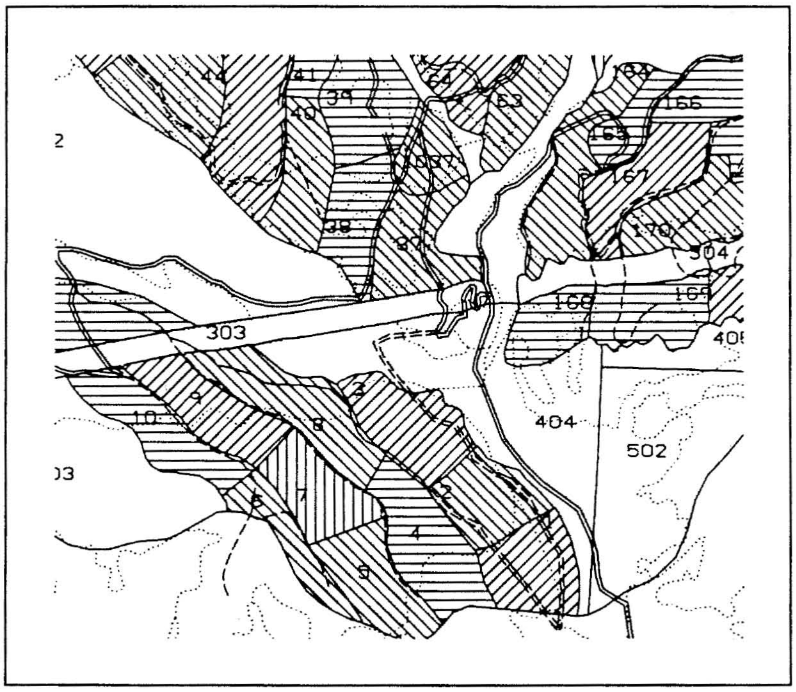

Figure 2. Typical cutblocks and forest-cover polygons in GIS database.

Table 1. Entry Screen for Harvesting Information

Productivity factors

Label ¦	Label	10
-----------------	Development Unit	BECKER
1	Year relative to Dev Unit	3
2	Calendar year for block	1998
3	Harvesting system	**RTS CC HANDF**
4	Productivity - Percent of base	100
5	Truck type	HIGHWAY/CON
6	Min to common point in DevUnit	10
7	Haul time -- text values	
8	Volume status:	
9	Entry_no	0
10	Cut_ref	CC
11	Grade_ref	NOGR
12	Silvicost	3400
13	Roadcost	0
14	Stumpcost	0
15	Overcost	2565
16	Othercosts	0
17	Fallerprod	160
18	Yarderprod	110
19	Loaderprod	300

The right-hand side of Table 1 shows a portion of the information stored for Cutblock 10, with the information about harvesting system highlighted. The left-hand portion of the table shows a partial list of all cutblocks in the database, with Cutblock 10 highlighted. This screen layout, with a list of all the records on the left and the details about one record on the right, is used throughout FRP.

TOPO

TOPO provides a menu-driven interface to TerraSoft GIS that makes processing repetitive functions easier than with the standard interface provided by the vendor. The standard interface for TerraSoft expects each map to be processed individually, whereas TOPO recognizes that the same functions will be applied to many maps for many projects. TOPO provides methods for recording and automating the steps for each map.

Of particular interest to users of FRP-SM is the ability to classify the project area using the British Columbia Biogeoclimatic Ecosystem Classification (BEC). The TOPO/FRP-SM implementation of this classification system uses terrain, soils, forest-cover, and spatial information to derive the BEC site series classification. These polygons are shown as dotted lines in Figure 3. When grouped according to silvicultural prescriptions and overlaid with the cutblock boundaries, the resulting polygons form the treatment units.

Instructions for using TOPO for general usage and for the BEC processes are in a Microsoft Word 6.0 document included with the FRP program files.

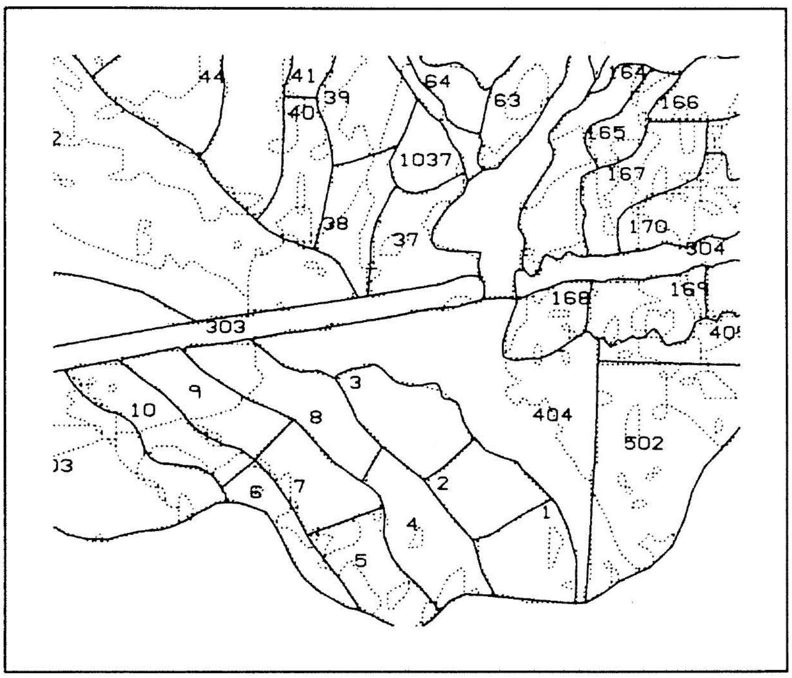

Figure 3. Typical cutblocks and treatment units.

Regardless of the method used for its creation, FRP-SM requires a database table for treatment units, and at a minimum, the database table must contain the following information:

- Treatment unit identifier.
- Treatment unit area.
- Date when management commences.
- Establishment date of original forest.
- Site-code identifier.
- Silvicultural prescription code.
- Regime code.

TOPO can generate this basic information using the databases from FRP-HM plus the biogeoclimatic and prescription classification systems. For users without TerraSoft GIS and TOPO, this information would have to be added to the treatment-unit database manually.

FRP-SM

The steps required to complete an FRP-SM analysis can be divided into four major phases: system-wide setup, project-specific setup, calculation, and reports.

System-Wide Setup

The models and definitions for FRP-SM are defined for the whole system and are applied to all projects. These tables must be configured properly before commencing analysis; a system administrator should be responsible for ensuring their correctness and completeness. The planner would be responsible for project-specific setup.

Ten items that must be defined are: parameters, curve types, curve sets, activities, prescriptions, difficulty factors, activity costs, regimes, suites and suite_id, and biogeoclimatic classification tables.

Parameters: Parameters are the generic names for the forest-development values that will be forecasted with FRP-SM; only those items defined as parameters can be modelled. A single parameter name can be used as a substitute for similar items from different growth models. For example, the *height* parameter might be defined as the field called *ht* from one growth model and *height_tip* in a second model. Table 2 shows the Parameter Definition screen in FRP-SM.

Curve Types: Curve types define the database structure for growth models by listing the names of the database fields and the name of the FRP-SM parameter associated with each field. The database table for each curve must contain a field for the independent variable (age) in addition to the fields listed in the curve-type definition.

Curve types can be defined for published models such as the BCMOF's VDYP and Tipsy models, as well as for localized models specific to a particular project. This system design makes FRP-SM very flexible for using models from a wide range of sources.

Curve Sets: A curve set represents a specific growth model on a specific site type after implementing a specific silvicultural treatment.

The data are stored in xBase-format files that list the value of each parameter as a function of age. The age increment between database records is variable; it can be narrow where a high level of detail is required and wider when the model is defined with less certainty. FRP-SM interpolates between database entries when calculating intermediate points. For forecasts before the minimum age or after the maximum age, FRP-SM uses the first and last database entries respectively as

Table 2. Entry Screen for Parameter Definitions

Filter Add Delete Utilities Cancel Save Browse

Parameter Definitions

Category	Description	Curve_type	Prio	Field_name
BASAL_AREA	Basal Area	TIPSY		BA
CROWN_CLOS	Percent of Crown Closure	CROWN_CLOS	1	CC_PCT
		TIPSY	2	CC_PERC
DBH	Diameter Breast Height	TIPSY	1	MEAN_DBH
		VDYP	2	DIAMETER1
HEIGHT	Tree height	SIWAP	2	HT
		VDYP	1	HT
		TIPSY	3	HEIGHT_TIP
		HEIGHT	4	HT_GEN
MERCHANTABLE 17	Volume Of Merch Timber > 17.	TIPSY		MER175
RECOVERY	Percent Of Hydrologic Recove	SIWAP	2	REC_PERC
		TIPSY	1	PLC_PERC
SNAG_HA	Snags per hectare	GEN_SNAG		SNAGONHA
STEM_COUNT	Stems/ha > 7.5 dbh	TIPSY		STEM_CNT
VOLUME 12.5+	Tree Volume > 12.5 dbh	VDYP		VOL125
VOLUME 7.5+	Tree Volume > 7.5 dbh	VDYP	2	VOL75
		TIPSY	1	GROSS0

constant values. A single file can contain data for many parameters, but they all must use the same age increment. Table 3 shows a typical curve set used by FRP-SM for growth modelling.

Activities: Activities are the basic cost components of FRP-SM. The user can define activities that are used in typical silvicultural prescriptions; examples include planting, spacing, and fertilizing. The costs for activities can be expressed in dollars per hectare or dollars per unit. The user must define a default cost for each activity to be used when there is no site-specific difficulty-factor information. (See following Activity Costs section.)

Prescriptions: Prescriptions are FRP-SM's method for assigning activities to treatment units. A prescription consists of a list of activities, the scheduled time for each activity relative to the commencement of management, and the amount of the activity to be undertaken. Table 4 shows the prescription definition screen from FRP-SM.

Table 3. Typical Curve Database for Growth Modelling

Curve: C:211.DBF

Age	Mean_dbh	Stem_cnt	Cc_perc
1	0.1	2655	0
11	1.7	2481	20
21	9.4	2168	89
31	17.1	1475	91
41	22.8	1157	90
51	27.9	940	88
61	32.6	784	87
71	36.9	663	86
81	41.4	551	84
91	45.9	459	83
101	50.5	382	82
111	54.2	334	80
121	57.4	298	79
131	60.5	267	78
141	63.1	243	76

Table 4. Entry Screen for Prescription Definitions

Prescription Def'n

ID	Name	Detail	perHa	Year	Activity	Base cost	Units	ID
0	NULL	Memo						
1	PLANT/THIN	Memo	1000	0	PLANT	0.15	$/EA	1
			1	15	THIN	800.00	$/HA	4
2	PLANT/FERTILIZE	Memo	850	0	PLANT	0.15	$/EA	1
			1	8	FERTILIZE	1000.00	$/HA	3
			1	15	THIN	800.00	$/HA	4
			1	15	FERTILIZE	1000.00	$/HA	3
3	PLANT750	Memo	750	0	PLANT	0.15	$/EA	1
4	PLANT800	memo	800	0	PLANT	0.15	$/EA	1

Difficulty Factors: In addition to the user-defined default cost for each activity, FRP-SM can calculate the cost of carrying out each activity depending on the site characteristics. FRP-SM uses attributes called *difficulty factors* to describe the characteristics of the site relative to the cost of undertaking an activity. The number and composition of the difficulty factors is left to the user, but in choosing the difficulty factors for the FRP-SM model, items that can be mapped in the GIS should be selected for ease of transfer to the treatment-unit database.

Activity Costs: The cost of undertaking each activity for each combination of difficulty factors must be entered into the system. FRP-SM uses the entry "NoData" when information about site-specific difficulty factors is missing; FRP-SM will use the default costs in this case. Table 5 shows the activity-cost entry screen from FRP-SM.

In this example, the cost of planting has been defined as dependent on the site's ground roughness, slash loading, and slope. The number of difficulty factors is limited only by the planner's need for more detail and ability to provide meaningful data; more combinations of difficulty factors will result in time-consuming data-entry requirements.

Table 5. Entry Screen for Activity Costs

```
Done   Fill Data   Help
     +-----------------------------------------------------------------------------+
     |+-----------++-------------------------------++----------------+             |
     || Activity  ||| Diff. Factors |Filter         ||| Values        ||            |
     ||-----------|||---------------+---------------+||----------------+|          |
     || PLANT     ||| Site ROUGHness|EASY           ||| NoData        ||  <Filter>|
     || FERTILIZE ||| SLASH LOADING |               ||| TOUGH GROUND  ||            |
     || THIN      ||| Avg. sideslope|               ||| MEDIUM        ||            |
     ||           |||               |               ||| EASY          ||            |
     ||           |||               |               |||               ||  <Clear >|
     ||           |||               |               |||               ||            |
     ||           |||               |               |||               ||            |
     |+-----------++-------------------------------++----------------+             |
     | PLANT Basic Cost: 0.15 $/EA                                                 |
     |   Site ROUGHness:  EASY                                                     |
     |+------------------------------------------------------------+ <Costs>      |
     || SLASHLOAD - |NoData |FLAT   |MEDIUM |STEEP |                | [X] Auto|   |
     ||-------------+-------+-------+-------+------+----------------|             |
     || NoData      |  0.15|  0.15|  0.22|  0.32|                  |             |
     || HEAVY       |  0.15|  0.17|  0.25|  0.35|                  |             |
     || LIGHT       |  0.15|  0.15|  0.17|  0.20|                  | <Done>      |
     ||             |      |      |      |      |                   |             |
     |+------------------------------------------------------------+              |
     +-----------------------------------------------------------------------------+
```

Regimes: FRP-SM uses *regimes* to control the prescriptions selected for a particular site for situations where identical sites require different silvicultural prescriptions. Regimes can account for factors such as travel distance influencing the choice of prescriptions.

Suites and Suite_id: For growth modelling, each treatment unit must be assigned a curve set for the time before management and another curve set for the time after management. The *suite_id* is the code that identifies the two curve sets so that they can be managed as one entity. Table 6 shows the curve sets associated with five suite_ids.

In addition, models from different sources can be used together in one suite_id. FRP-SM will select the appropriate curve set depending on the parameter being modelled and the priority between the curve sets as shown in Table 2. In the example shown, three of the suites are each associated with three curve types, one suite with two curve types, and one suite with just one curve type.

Biogeoclimatic Classification Tables: These tables are used by the TOPO BEC site series classification system; they are not used by FRP-SM *per se*; however, they are part of the same overall system and are maintained within FRP-SM. The tables describe the various biogeoclimatic site units and the combinations of soil moisture and soil nutrient regimes which determine the site series. In addition, there are tables that group various site series into classes called *frp_site*. The frp_site is used to assign the suite_id and prescription_id to each treatment unit.

Project-Specific Setup

Each project must exist in its own MS-DOS directory. Prior to commencing FRP-SM, the user should create a treatment-unit database table with the GIS, and populate it with data for all the treatment units.

Scenario Definition: A scenario is a database table of values that are forecasted after applying silvicultural prescriptions to the treatment units in accordance with a harvesting schedule. The scenario definition specifies two database tables, that is, the data source data (treatment units) and the storage location for the results.

Table 6. Suite Definition Screen Showing Multiple Curve-Types Per Suite

Suites / Curves

ID	Name	Desc	Date	Managed Crv	Wild Curve	Type
1	ONE	Memo	08/03/95	22M.DBF	24M.DBF	VDYP
2	TWO	Memo	08/03/95	REC2.DBF	REC6.DBF	SIWAP
				11M.DBF	101.DBF	VDYP
				TIP0.DBF	TIP1.DBF	TIPSY
3	THREE	Memo	08/08/95	REC3.DBF	REC6.DBF	SIWAP
				11P.DBF	101.DBF	VDYP
				TIP0.DBF	TIP2.DBF	TIPSY
4	FOUR	Memo	08/08/95	REC4.DBF	REC6.DBF	SIWAP
				1P.DBF	1M.DBF	VDYP
				TIP0.DBF	TIP3.DBF	TIPSY
5	FIVE	memo	12/09/95	10P.DBF	11M.DBF	VDYP
				TIP0.DBF	TIP4.DBF	TIPSY

The essence of the scenario definition is to choose the parameters to be forecasted and to choose the dates for forecasting their values. For example, the planner could choose to forecast the value of crown closure percentage in the year 2020 or 2050. When the scenario is processed, FRP-SM will examine each treatment unit in the planning area and determine the following:

- The date that management is scheduled to commence.
- Whether the scenario forecast date is before or after the management date.
- Whether to use the managed curve set or the wild curve set.
- Which curve to use for the particular parameter.

Using this information, FRP-SM forecasts the value of each parameter to the date specified in the scenario definition. A scenario can contain up to 15 combinations of parameters and forecast dates.

A scenario is specific to the project for which it is defined; changing the scenario definition for one project will have no impact on a like-named scenario for any other FRP-SM project. Scenarios can be saved in templates so they can be used in subsequent projects.

Prescriptions and Suites: Each treatment unit must be assigned with a prescription code and a suite_id code. The prescription code designates the activities that are scheduled for the site, and thus, the costs for the silvicultural activities. The suite_id code determines the set of curves that will be used for forecasting the future values of the parameters.

If the treatment-unit database is created using the TOPO classification system for prescriptions, then this information is included automatically. Otherwise, a linkage table assigns prescriptions and suite_ids depending on the BEC site series. As a last resort, the values can be entered manually through FRP-SM entry screens or through GIS overlay functions.

Difficulty Factors: The difficulty factors must be entered into the treatment-unit database before cost calculations can be done. Presuming that the GIS database has information about difficulty factors, this is best accomplished using GIS overlay functions to copy key information from the difficulty-factor spatial databases to the treatment-unit database.

If the difficulty factor information does not exist in the GIS database, then the factors must be entered manually or FRP-SM will use the default costs for all activities.

Calculations

Costs: The costs in FRP-SM are calculated from information about the prescriptions and difficulty factors for each treatment unit, and unit costs for each activity. Costs can be calculated as summaries or in detail; the costs can be included in the standard FRP-HM reports when calculated in detail. All the costs calculated from FRP-SM are classified as "silviculture" costs with respect to the subtotalling functions for reports in FRP-HM.

Detailed costs show the individual activities for each treatment unit, including the date that they are scheduled to occur. The dates are derived from the scheduled harvesting date for the cutblock plus the time-lag as defined in the silvicultural prescription. Table 7 shows the typical results of calculating the activity costs for one of the cutblocks.

Scenario: A scenario is a series of "snapshots" of the status of various parameters at various points in time. These snapshots can be reported in tabular format or displayed as a colour-theme map in the GIS.

When calculating the future value of the parameters, FRP-SM uses the scheduled harvesting date for the cutblock to determine the elapsed time to the snapshot date. If harvesting dates are entered to the nearest year, then results will be calculated to the nearest year, but if harvesting dates are

Table 7. Detailed-Cost Entry Screen for Cutblock 10

```
Costs attributed to the BLOCK
  Description of cost            |  Description of cost     264:   PLANT
---------------------------------|  Cost for block:         10
  264:   PLANT                      Type of cost            SILV_CALC
  309:   PLANT                      Amount                   1032.75
  264:   FERTILIZE                  Units of Measure        $/EA
  264:   THIN                       Road Class
  264:   WEED                       Relative year of cost
                                    Absolute year of cost 2043
                                   ------------------------------------
                                    Description of cost     309:   PLANT
                                    Cost for block:         10
                                    Type of cost            SILV_CALC
                                    Amount                    886.95
                                    Units of Measure        $/EA
                                    Road Class
                                    Relative year of cost
                                    Absolute year of cost 2043
                                   ------------------------------------
```

entered to the nearest 10 years, then FRP-SM will use 10-year increments for its calculations and the program will run faster. Variable times can be used if desired, with annual increments for early portions of the planning horizon and longer intervals for the latter portions.

In Figure 4, FRP-SM has calculated the crown closure to the year 2020, including the effects of harvesting, silvicultural activities, and growth. Notice that the crown closure for Cutblock 9 is not uniform—the two treatment units have been assigned to different growth curves according to their biogeoclimatic site series classification. Some cutblocks are unshaded because their crown closure percentage in the year 2020 is projected to be less than 10 percent, which was used as an arbitrary limit for the thematic shading.

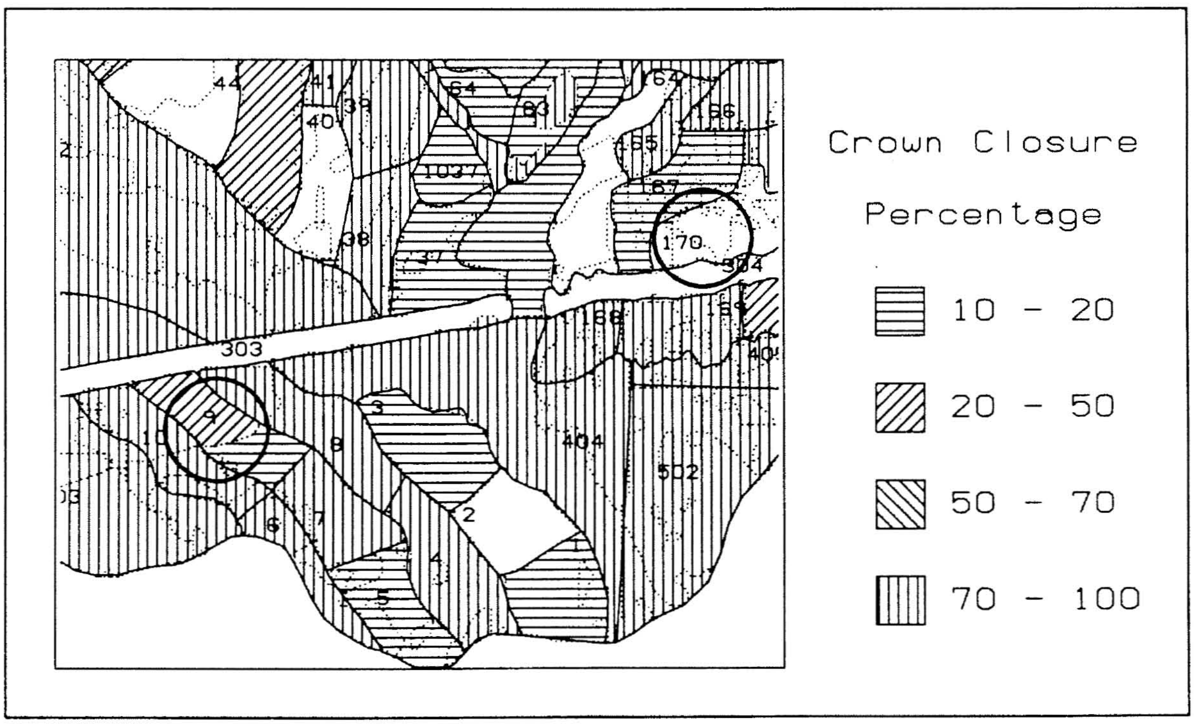

Figure 4. Scenario results showing crown closure percentage in year 2020, with two cutblocks highlighted.

Reports

FRP-HM includes a series of standard reports for costs and volumes, and the detailed costs for the silvicultural activities are integrated into these reports. Table 8 shows a portion of a cost summary report from FRP-HM, including the silviculture costs as calculated by FRP-SM. The cutblocks for the report in Table 8 include all the cutblocks in a watershed, not just those from one specific year. The analysis was for harvesting and silvicultural costs only, and not for road, stumpage, or other costs.

Since FRP-SM uses an open design in which the planner can model almost any parameter, it is impractical to create specific reports that will be applicable for more than a single location or user. Instead, by providing access to the FoxPro report writer, users of FRP-SM can make customized reports that satisfy their particular needs. Such customized reports can be used for any subsequent FRP-SM projects.

In addition to being printed in tabular reports, the scenario results can be displayed in the GIS. Since each record in the scenario database table is associated with one treatment unit, the GIS must provide a mechanism for joining the two tables in order to use the scenario results for thematic shading. The specific steps for making the colour-theme maps will vary among GIS, but in TerraSoft, the "Database View" command provides the method for linking the treatment-unit polygons with the scenario-results database table.

Figure 5 shows the type of map that can be generated using the scenario database table. In this example, the projected crown closure for the year 2050 after implementing a harvesting schedule and silvicultural plan is displayed in a thematic map. Compare the map with Figure 4 which shows the projected crown closure in the year 2020. The differences reflect the results of harvesting and growth between the two periods. Note that Cutblock 9 continues to have different values between the two treatment units as does Cutblock 170. In the previous map, all of Cutblock 170 had the same value.

Table 8. Portion of Block-Cost Report for an Entire Project Area

Block Costs:			
Direct Harvesting Costs:			
FALLER	2,603,942		
YARDER	5,847,037		
LOADER	3,124,732		
OTHER #1	0		
OTHER #2	0		
HAUL COST	4,585,613		
Subtotal:		16,161,324	10.54
Other Block Costs:			
OVERHEAD		1,183,616	0.77
ROAD		0	0.00
SILVICULTURE		19,247,967	12.56
STUMPAGE		0	0.00
OTHER		0	0.00
Subtotal:		20,431,583	13.33/m3
Block Total:		36,592,907	23.87/m3

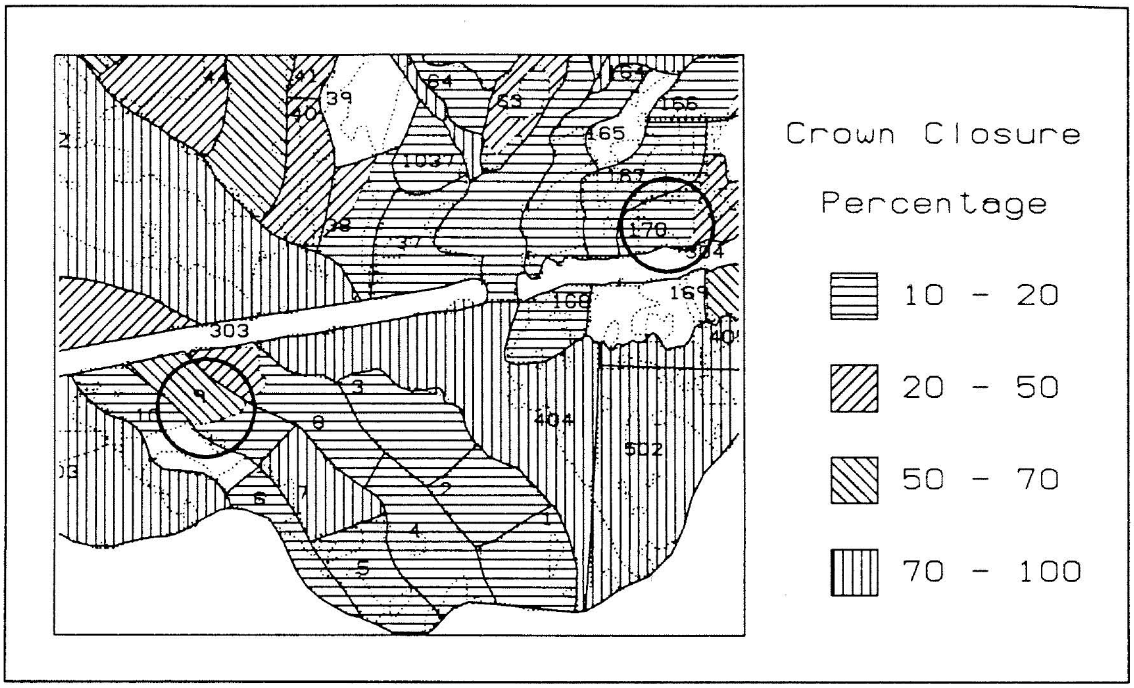

Figure 5. Scenario results showing crown closure percentage in year 2050, with two cutblocks highlighted.

DISCUSSION

Using FRP for Project Analysis

FRP combines harvest- and silviculture-planning programs to provide forest planners with a personal computer environment for doing area-based planning using a GIS. The software package includes database structures and theme definitions for TerraSoft GIS so that the planner does not have to create these basic data structures for himself, but instead can start with a working solution. Using the harvest module, the planner can calculate timber volumes and values, and the costs and net revenues of the planned harvesting activities. The silviculture module can calculate silvicultural-treatment costs and forecast the forest development resulting from different harvesting and silviculture activities. Both modules can be customized for local conditions.

The fundamental land unit for harvest planning is the cutblock; cutblocks can be further divided into areas called treatment units for use with the silviculture module. Where they have already been determined by fieldwork, the treatment unit boundaries can be entered into the GIS manually. However, FRP includes a classification system for creating treatment-unit polygons by way of a biogeoclimatic interpretation of information contained in the GIS. It also has the capability of further classifying the polygons by proposed silvicultural prescriptions. This capability provides the beginning for a method to choose the location for cutblock boundaries and site treatments according to biogeoclimatic criteria. Further development of this system was beyond the scope of the project, but could be the focus of future work.

Using FRP-SM and the GIS, the planner can create colour-themed maps showing the forest development that will result for each treatment unit after implementing the harvesting plan. These colour-themed maps can show the values of any parameter of the planner's choosing, and can be created for any time in the future. For example, the planner could generate a series of crown-closure maps at specified intervals for use in habitat or viewshed-quality analysis. FRP also produces results in tabular form for printed reports or subsequent analysis in spreadsheets or databases.

Growth Modelling

The growth modelling in FRP is an open system in which almost any external model can be registered and subsequently attached to the treatment unit polygons for analysis and display. Each set of growth curves registered in FRP represents the growth on a specific site type for a specific silvicultural prescription, and the planner must ensure that each combination of site types and silvicultural prescriptions is represented with a valid set of growth curves.

An early goal for FRP was to create a system where the planner could interactively assign individual treatments to specific treatment units, and for the system to dynamically alter the growth models accordingly. However, this proved to be unworkable because the combinations of sites and treatments grew exponentially until it became an overwhelming data-management problem. The solution was to explicitly associate curves with treatments.

The site-description index for growth could have been any existing measure such as the BCMOF Site Index, but one of the objectives of the project was to base the modelling on a biogeoclimatic site classification. This required making an equivalence between the BEC classification and the growth curves that would be used. A generalized index called frp_site was created and used to classify both the site index and the growth models. FRP links the treatment units to specific growth curves based on the frp_site for the treatment unit.

This approach results in a flexible system where various models from different sources can be included by applying equivalence factors between their site-description index and the frp_site.

Operating Environments

FRP is primarily a data-storage and bookkeeping system, and requires that data be entered, manipulated, and displayed in separate GIS and database application programs. The linkage between the GIS and database program is limited to a set of common goals and a series of shared database tables.

There have been substantial changes in computer hardware and software technology in the past few years. When development of FRP-SM was started, MS-DOS–based programs on 386-class computers were common; now the accepted standard is Windows-based software running on 486 or Pentium-class computers. Many GIS implementations use even more powerful hardware and software; most corporate GIS run under the UNIX operating system. Regardless of whether UNIX-based or Windows-based, users now expect to run programs simultaneously and link the programs through cut-and-paste or more sophisticated technologies. Application programs such as FRP that are based on FoxPro and TerraSoft run independent of one another; therefore, integration remains at a more basic level.

GIS-Based Applications Required

The FRP-SM software represents one approach to area-based harvest and silvicultural planning as described above. Three programs demonstrated at a software workshop held in Vancouver (MacDonald 1995) use a different approach to determine the harvesting schedule. ATLAS (Nelson 1994), SNAP II (Sessions 1992), and GIS COMPLAN (Anonymous 1995) all use a technique called simulation and all have the ability to determine harvesting schedules for sets of cutblocks according to rules such as adjacency, cutblock size, and forest-cover composition.

With these three simulation programs, the planner starts with a set of cutblock boundaries and a road network plus a database of harvesting constraints. The software examines the list of cutblocks and chooses which cutblocks to schedule at each point in time in order to achieve various goals without violating the constraints. The planner is able to modify the constraints in order to see their effect on the harvest schedule. These programs work quite quickly; the planner is able to see the results of a change in constraints in just a few minutes, as compared to the multiple steps required to accomplish the same tasks with FRP. Additional information about these three programs can be obtained from their respective authors.

However, with the simulation programs, there is a presumption that the set of candidate cutblocks for scheduling has been entered into a GIS database. Two of the programs further presume that the data for the cutblocks have been exported from the GIS to the scheduling program; only GIS COMPLAN works with ArcInfo files in their native format and does not require the data-exporting steps. ArcInfo is a GIS used by many forest companies.

FERIC believes that systems based on the assumption that existing GIS databases can be exported to harvest-scheduling software may have the following shortcomings:

- While proposing cutblock boundaries on the map, the planner needs access to the regulatory information that determines where the boundaries are permitted to be located, so that he can modify the boundaries as required. With separated GIS and the harvest-scheduling software, the rules can be applied only to a static set of cutblock boundaries. In FERIC's opinion, this is too late to apply the rules; they must be applied while the cutblock boundaries are being proposed. The regulatory information can be best stored and used in a GIS environment.
- The location and scheduling of one cutblock can influence the location and scheduling of an adjacent cutblock. The planner should be able to see these relationships *while* proposing the boundaries so that modifications can be interactive.
- The time lag between creating a GIS database and its analysis in the harvest-scheduling software will make this approach unworkable for ad-hoc analysis. The time lag would be especially onerous if the GIS was maintained at a different location; the GIS is often maintained remotely by a consultant on behalf of the forest company. In order to avoid reprocessing the GIS database for each change in cutblock boundaries, simulation software is often used on a pre-determined set of "atomic" polygons that can be combined into "real" cutblocks. However, the "real" cutblocks may not necessarily reflect feasible or desirable boundaries as laid out on the ground.
- Once the analysis with the harvesting scheduling software is completed, the real boundaries must be entered into the GIS database in preparation of submission to the agencies for approval. Depending on the amount of flexibility in the harvesting regulations and the correlation between the boundaries of the atomic polygons and the real cutblocks, the planner may have to re-analyze the harvesting schedule using the real cutblock boundaries.

This is not to say that the simulation software does not have a place in the planning cycle. FERIC believes that instead of being used to make harvesting plans for submission to the regulatory agencies, simulation software is better suited to examine the effect of various policies and prescriptions on sample operating areas. The results of the simulation software would then be incorporated into a GIS-based planning system.

Role of GIS-Based Planning Software

FERIC believes that software similar to FRP-SM will allow the planner to store corporate information about the forest and to propose various harvesting plans in a GIS environment. This software will also be used to produce the final plans for submission to the regulatory agencies for approval.

However, upon examining FRP as a delivery model to accomplish this concept, some weaknesses emerge:

- Software based on FoxPro and TerraSoft is not flexible, powerful, nor robust enough for corporate-wide application.
- It is not sufficiently interactive. The software must allow the planner to propose new cutblocks and immediately see the implications on their neighbours, instead of the current method of creating a GIS database and then analyzing it in a separate process.
- FRP does not have the ability to aggregate results from individual projects into an overall plan for a larger operating area.
- FRP is limited to a single harvesting system in each cutblock.
- Each company where FRP was demonstrated has its own database design for managing information about harvesting and silvicultural activities. FRP has some flexibility for adapting to different information requirements, but the core information used by FRP is stored differently for each company, and none of them match the data structures of FRP. In order to use FRP, the companies would have to maintain two sets of data, use a data-translation step, or change their existing data to match FRP'S requirements.

For a single program such as FRP to be usable with different corporate database designs, one of two changes must occur. The software must either be able to adapt to different corporate database designs, or the corporate databases must be standardized. Both of these options were beyond the scope of the current project, but could be the foundation of future development work.

CONCLUSIONS

This project set out to develop a software system that included four new capabilities over the existing FRP-HM software. These capabilities were to:

1. Implement methods for planning all silvicultural activities for each site.
2. Implement a computer model for estimating the costs of silvicultural treatments on a site-specific basis.
3. Implement a method for classifying the forest into unique areas that incorporate both site growth potential and proposed harvesting schedules. The basic land unit would be derived from a GIS overlay of the biogeoclimatic classification and the proposed harvesting plan.
4. Implement a computer model for forecasting forest development.

The resulting software, FRP-SM, accomplishes these tasks in a map-based environment. It provides the planner with a method of inputting harvesting and silviculture plans, and predicting the forest development as a result of those plans. A single plan or several plans can be developed for each analysis area.

For the most part, the software uses a non-proprietary approach; it can be used with any GIS that supports the xBase file format for attribute information. It can even be used without a GIS, although input and output capabilities would be severely restricted. A GIS-based biogeoclimatic classification system was developed for deriving BEC site-series polygons from other GIS data, but this system is available only with the TerraSoft GIS.

The role of FRP in forest planning is unclear. Other harvest-scheduling software based on simulation techniques automatically perform some of the functions that are done manually in FRP, and these programs attract considerable attention. However, these programs rely on the existence of completed GIS databases for cutblocks and road networks, and FERIC believes that new tools are required to aid the planner in the development of these GIS databases. Such tools must provide the planner with immediate feedback about the feasibility of the cutblock boundary projections without the delay associated with exporting the data to a harvest-scheduling program. FERIC believes that GIS-based software similar in concept to FRP will play a pivotal role in the generation of these GIS databases by providing the immediate feedback between boundary projection and analysis.

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GLOSSARY

Term	Definition
activity	Basis for cost calculation in FRP-SM, e.g., planting, thinning.
area-based planning	Harvest-planning for a specified tract of land in which the proposed management for every part of the tract is identified regardless of when the management is scheduled to occur. As opposed to time-based planning where only portions of the tract of land are identified in the plan.
atomic polygon	Area smaller than an operational cutblock; a "building block". Used in simulation software, and meant to be combined with adjacent atomic polygons to form operational cutblocks.
attribute	Item in a database table which describes the value of a particular characteristic of a polygon.
Biogeoclimatic Ecosystem Classification (BEC)	Land classification system used in British Columbia to describe the bio-physical characteristics of a site. In FRP, a classification system based on the Ministry of Forests Kamloops Region implementation of the BEC, that uses soil moisture and soil nutrient indices to derive the classification.
colour-themed map	Map produced by a GIS that displays the value of a selected attribute according to a specified colouring scheme.
curve	Relationship showing the value of a selected parameter as a function of age.
curve, managed	Curve set to be used after management commences on a site.
curve, wild	Curve set to be used before management commences on a site.
curve set	Database containing several related curves. Each curve shows the value of a different parameter as a function of age. The age base must be the same for all curves within a curve set.
curve type	A particular class of curve set. Describes the field names in the databases and the FRP-SM parameters that they are linked to.
cutblock	Smallest unit for harvest scheduling.
database	A set of database tables about a particular topic with a well-defined organization and relationship among the tables.
database table	A subset of the data within a database. Organized in a row-and-column fashion where the columns represent different attributes and the rows represent different items. Records is a synonym for rows.
development unit	A level of organization for cutblocks used for summarizing costs and volumes. Typically defined as all the cutblocks tributary to a specific branch road.
difficulty factor	Physical factor that affects the cost of carrying out different silvicultural activities. Should be able to be mapped in the GIS.
digitize	The act of tracing a map on an electronic tablet for input to a GIS.

forest	The highest level of organization in an FRP project. Each FRP project consists of exactly one forest.
FoxPro	A database management system produced by Microsoft Corporation, Redmond, WA. Uses xBase files as its native file format.
FRP	Forest Resources Planning. A database programs for organizing GIS databases for harvesting and silvicultural planning. Computes harvesting and silvicultural costs and timber volumes and values; forecasts the future forest condition and makes it available for mapping in a GIS.
FRP-HM	FRP–Harvest Module. The portion of FRP concerned with calculating and reporting harvesting costs and the volumes and values of the timber flowing from the planning area.
FRP-SM	FRP–Silviculture Module. The portion of FRP concerned with calculating the costs of silvicultural activities and projecting the results of those activities into the future.
frp_site	An index that links each treatment unit to the silvicultural prescription ID and the suite ID that are used for calculating costs and projecting growth respectively.
georeferenced database	That portion of the FRP-SM database derived from the GIS.
GIS	Geographical information system. The hardware and software required to create, edit, store, display, and analyze spatial databases.
grid	One type of data representation in a GIS in which the area is divided into a uniform coverage of cells. The value of each cell is uniform, and the boundaries between cells are rectangular. As opposed to a polygon.
linework	Map lines as represented in a GIS.
management	The application of a silvicultural prescription to a treatment unit.
model	That portion of the FRP-SM database that describes the costs of various activities and the projected growth as the result of applying a particular silvicultural prescription to a particular site type.
overlay	GIS technique for combining two or more sets of polygons to produce a new set of polygons that comprise the intersection between the original polygons.
parameter	The generalized name for an attribute of a growth model. Using parameters allows growth models of different origins to be used within the same suite_id.
polygon	The GIS representation of a parcel of land. The polygon boundaries are described by a series of digitized lines. As opposed to a grid cell. Each polygon is linked to one record in a database table.
prescription	A set of silvicultural activities that identifies the amount of each activity and its scheduled date after management commences.

regime	An index that describes the prescription and suite_id to be used for each frp_site. Allows for different treatments to be used for the same site type on different portions of the planning area.
scenario	The description of which parameters to be forecasted and the dates for which they are to be forecasted. Also, the database table that results from running the scenario calculations.
suite, suite_id	An index that lists the curve sets to be used for growth modelling for each treatment unit. It lists the curve sets to be used before and after management.
TerraSoft	An MS-DOS–based GIS produced by Essential Planning Systems, Victoria, B.C.
theme	A TerraSoft term for the linkage between a set of polygons and a database table.
Tipsy	A yield model produced by the British Columbia Ministry of Forests for use with managed stands.
TOPO	A program for TerraSoft GIS for automating the steps required for creating TerraSoft themes.
treatment unit	A subset of a cutblock; the smallest unit for silvicultural cost calculations and growth forecasting.
VDYP	A yield model produced by the British Columbia Ministry of Forests for use with unmanaged stands
watershed	An autonomous land unit used as a basis for FRP planning. Typically in the range of 5 000 to 20 000 ha.
xBase	A standard format for PC database files. Originated with the dBase database management program.