APPENDIX VI

Twenty-year Development Plan

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TREE FARM LICENCE 55
TWENTY-YEAR PLAN

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Prepared for

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INTRODUCTION

This document describes the 20-year paper plan for Tree Licence 55 (TFL 55), which spatially locates the first 20 years of the projected timber harvest produced by the Timber Supply Analysis.

There is only one objective for the 20-year plan:

- to locate on paper the first 20 years of the recommended harvest level developed from the timber supply analysis.

The 20-year plan is not an operational plan. Because the object is to test the result of a Forest Estate model, salvage blocks should not be part of the test. These are blocks that are additional to normal harvesting. It is important to show that we can spatially locate recommended harvest levels without reliance on the volumes from salvage blocks.

In practice, the salvage blocks will be harvested and will affect patch size distributions. The Ministry of Forests (MoF) has requested statistics on present and future patch size distributions. Therefore, in our calculations of patch size distributions we have included salvage blocks. Salvage blocks have also been shown on our maps of the 20-year plan

METHODS

Sterling Wood Group has used our proprietary spatial harvesting model, PRISM to develop the 20-year plan for TFL 55. PRISM stands for "Patterns for Resource Integration and Spatial Management". This model is described in the following pages.

THE PRISM SPATIAL MODEL

There is more in the forest than just timber.

Until recently, time has been a major determinant of resource production schedules. Today, the implementation of forest plans demands spatially feasible prescriptions.

The emergence of Geographic Information Systems (GIS) has given us the capability to build, store and display large amounts of spatial data. Pretty maps of any shape and size which display GIS data are now routinely produced, and are very useful. But the resource issues of today need more than theme maps and data summaries in order to be resolved. Spatial issues demand spatial analysis for their resolution. Sterling Wood Group Inc. (Victoria) / Inland Timber Management Ltd. (Williams Lake) have spent the past three years carefully developing an advanced spatial resource simulator which opens new approaches to building spatially feasible management prescriptions. This tool allows us to describe and manipulate the spatial mosaic of forest resources from different points of view. PRISM provides users with the capability to identify a variety of resource management objectives and illustrate a spatially defined 'mosaic' of units which meet the specified criteria. The resource units may be labelled differently by different disciplines. In BC the word 'patch" is often applied to a single resource unit.

Natural resource data sets belong to some location in space. Spatial continuity exists in most resource data sets. When data sets are represented as spatial grids, two data close to each other are more likely to have similar values than two data that are far apart. Since there are usually multiple resource variables to be found at each location (timber, visual, wildlife, soil stability etc.), there are many ways to analyse and describe the spatial continuity of mutual resource data. The idea of 'patches' is one way to do this. For example, a forest cover map shows a version of 'patches' for forest cover according to a set of written procedures and defined values for forest cover. If the forest cover map is regularly gridded so that each point on the grid carries the relevant data values, then the cover map can be thought of as a symbol map. A symbol map replaces each data point on the grid with a symbol that denotes the class to which the data value belongs. Symbols used in forest cover maps include tree species, height, age, stocking class etc. All those data points on the grid having the same symbols are combined into the same forest polygon.

Other resource values or symbols, like slope stability classes, can also be attached to the same grid that was used for the cover map. Now resource patches may be defined in terms of soil stability only, or soil stability and forest cover combined.

Obviously there are many ways of defining resource patches based on spatially located resource data. But another factor – human intentions for resource use – multiplies yet again the possibilities for defining resource patches. For example, a particular forest type may occur in large patches averaging 300 hectares in size. We may decide to log these areas in much smaller patches, averaging only ten hectares in size, but ranging from a minimum of three hectares to a maximum of 30 hectares. Overlaying this intended pattern of use on the patterns inherent in the resource data will generate a completely new distribution of patches. Yet another factor affecting patch sizes is the similarity rules we apply to the underlying resource data. For example we may count as one patch, any group of adjacent forest polygons that have the same leading species and are within the same 20-year age range.

In summary, there are three factors affecting the definition of a 'patch'. These are:

- the available biological and earth science data;
- the resource use policies/management strategies that will be applied to a given zone;
- the similarity rules that are used to define the variation allowed within a single patch.

In the PRISM model a special component constructs resource units or 'patches' for the entire forested landbase. Resource units are constructed to meet criteria such as minimum, maximum and most frequent sizes, management emphasis zones, specified forest cover attributes, site productivity, topographic feature etc. PRISM resource units may cross polygon boundaries or subdivide single polygons or combine complete and partial polygons. The objectives for constructing resource units will vary but may include uses such as definition of harvesting units, old growth area or other specific land growth areas or other specific land use designations areas.

By varying the specific values of the three factors affecting the definition of a 'patch', PRISM will construct new patterns of resource units. This allows us to see how different values will change spatial patterns of resource units. It also allows us to see when a given set of rules will not produce the patterns of resource that we are hoping for.

Once a particular population of spatial resource units has been built, a second component of PRISM develops an efficient schedule of timber harvests from the resource units. This component of the model provides a concise summary of how the management unit changes over time. From a harvesting perspective, scheduling can be conducted for either short or long term planning horizons, depending on the specific needs of the user.

PRISM DATA SOURCES

The model relies on readily available source information such as:

- Resource Inventories
  - Forest cover
  - Wildlife
  - Terrain and ecosystem
  - Recreation
  - Biogeoclimatic zonation
  - Land base net down definitions...
- Forest Policy
  - Biodiversity Requirements
  - Harvesting specifications
  - Silviculture Systems...
- Land Use Designations
  - Wildlife areas
  - Old Growth Management Areas
  - Visually Sensitive Areas...

PRISM APPLICATIONS

Potential applications for the output include, (but are not limited to) the following:

- Total Resource Plans
- Landscape Unit Plans
- Area based resource planning
- Identification of specific management areas
- Forest Resource land use negotiations
- Area/Volume based regulation analysis
- Forest Structure design analysis
- Sustainability Analysis
- Resource Costing Policies

Design Features

Following is a summary of several powerful features that have been incorporated into the basic architecture of PRISM.

Controlling Patch Size Distribution

For each separate management zone, PRISM requires a separate patch size distribution. For each management zone the user supplies PRISM with a minimum patch size, a maximum patch size and a preferred (most common) patch size. PRISM uses some internal mathematical equations to generate a probability density function (PDF) which has the desired properties. When building units, PRISM explicitly attempts to produce the patch size distribution defined for each management zone by its probability distribution.

Specific size rules, or the patch size distributions implied by the biodiversity guidebook can be supplied to PRISM as targets. Any required patch size distribution can be applied as targets to any relevant combination of layers present in a GIS coverage. For example, patch size distributions specific to a natural disturbance type (NDT), or NDT/visual zone combination, or NDT/harvesting system can be supplied to and used by PRISM.

Maintaining Structural Integrity of the Resource Base

With PRISM, any desired structure of any of the physical resources can be specified at any time in the planning horizon, not just as a final state. Structural requirements for habitat areas, seral stages, forest age class, species composition, or any physical characteristic in a GIS coverage can be explicitly stated by the user and supplied to PRISM. Physical resource design requirements can be supplied to PRISM for any individual time period, or for any subset, or for all time periods.

For example, if the existing age class structure in the ESSF zone is required to change to another structure over the next 50 years, and then remain constant thereafter, these requirements can be explicitly supplied to PRISM. The model will produce a spatial harvest that meets these requirements for structural change in the ESSF. At the same time that age class structure design requirements are complied with, the target patch size distribution of cut blocks will also be in force.

Developing Units Across Polygon Boundaries

Over the past 40 years, each successive forest inventory has created smaller forest polygons than the one before. Today, the technical specifications for forest classification influence polygon size and therefore influence polygon size distribution.

In the field, resource unit boundaries may lie within a forest polygon, or they may cross polygon boundaries. When patch size distributions are constructed from forest inventory polygons, they may bear little resemblance to those presented in the biodiversity guidebook.

For loggers and for wildlife, their view of the forest resource may not be represented by inventory manuals. For example, a grizzly bear moving down from high meadows to lower elevation berry patches may use a movement corridor influenced by topography and general ease of movement, rather than polygon type. The spatial model will cross-forest polygon boundaries to construct its units. When this happens, the different forest cover attributes of each part of the block are retained and used by the model in constructing a harvest schedule. The user tells PRISM which kinds of forest polygon can be included in the same resource unit. These instructions are called 'similarity rules'. For instance, the user may tell PRISM that as long as two adjacent polygons have the same leading tree species, the same age class and both have reached a minimum harvestable volume, then a single cut block can cross the polygon boundary to include all or parts of the two polygons.

Meeting Harvest Profiles

Constraints on harvest volume; harvest area and harvest profile can be supplied to PRISM for any, or all, time periods. Step down, even flow or any other harvest volume flow over time can be produced. The total harvest can be partitioned by management zone, forest type, geographic area, harvest system, age class, product type or any other attribute or layer contained in the GIS coverage.

The capability to control harvest profiles, combined with the capability (described earlier) to manipulate the structure of the resource opens the door for the spatial simulation of many forest management strategies. For instance, a short-term emphasis on logging lodgepole pine to combat mountain beetle attacks can be simulated. At the end of the 'beetle logging' a new harvest profile can be specified by the user.

Exploring Sustainability

There are many possible definitions of sustainability. For example, sustainable timber harvesting can be defined as equal volume harvests or equal area harvests. If the equal volume criterion is used, then the area disturbed by harvesting will fluctuate over time. If the equal area criterion is used, then the annual area disturbed by harvesting will stay constant but the volume harvested will fluctuate.

The structure and design of PRISM allows different definitions of sustainability for both timber and non-timber resources (e.g. critical winter range) to be specified by the user. Once specified, their effect on timber harvests, spatial and temporal resource structures can be compared.

Financial Constraints

Delivered wood cost constraints can be supplied to and used by PRISM. Different costs for different logging systems, forest types, geographic areas or any combination of these can be used by PRISM to:

- spatially define the economic wood supply,
- determine incremental costs of proposed resource management policies.

Any logging or log purchase program in a given market will have a target number for the average delivered wood cost (DWC). When delivered wood cost data are supplied to PRISM then the required average delivered wood cost for the total harvest can also be used as a constraint. Delivered wood costs for some parts of the harvest will be higher than the required average; some will be lower; but the overall average will be that specified by the user. In this way, for a given set of multiple resource management policies, and a given market condition, the spatial harvest produced by PRISM is a spatial definition of the economic wood supply.

Now, suppose one of the management policies is changed. For example, maximum block size is changed; or the width of riparian reserves; or biodiversity is applied at the site series level. Then, PRISM can be re-run with the new policy but the same delivered wood cost requirements. The difference in the spatial harvest with the new policy is the cost or benefit in terms of volume. Then, the average delivered wood cost can be changed until the harvest volume is equal to that from the original policy. The financial cost of the new policy equals the per cubic metre difference in DWC multiplied by the total volume harvested. In this way, any timber or non-timber policy change can be costed in terms of volume and dollars.

Silvicultural Systems

PRISM can simulate clear cutting and, to a limited extent, selective harvest silvicultural systems. When selective harvest systems are used which leave a green condition after harvest, there are no adjacency requirements. For example, the final felling of a shelterwood system is not made until the next crop has been established underneath the overstorey.

In the present version of PRISM the area receiving the first entry of a selective system must be specified by the user for each time period.

Growth and Yield

Every unit defined by PRISM is assigned one or more yield tables where a unit contains parts of two or more polygons; a separate yield table is used for each contributing polygon. Total yield is calculated from the contributing polygons and the area of each polygon within the unit.

Adjacency and Green-up

For a block to be harvested, all adjacent blocks must be as old, or older than the green-up age that applies to them. For each block, PRISM maintains a list of adjacent blocks. Regeneration delays are explicitly stated for each block.

In aspatial forest estate models, the effects of adjacency and green-up are modeled indirectly by specifying a maximum allowable area below a green-up age. In PRISM, the specific adjacency rules make aspatial rules unnecessary. However, aspatial area constraints can be prescribed if required. For example, the user can require 33% of the total operable area to always be less than green-up age.

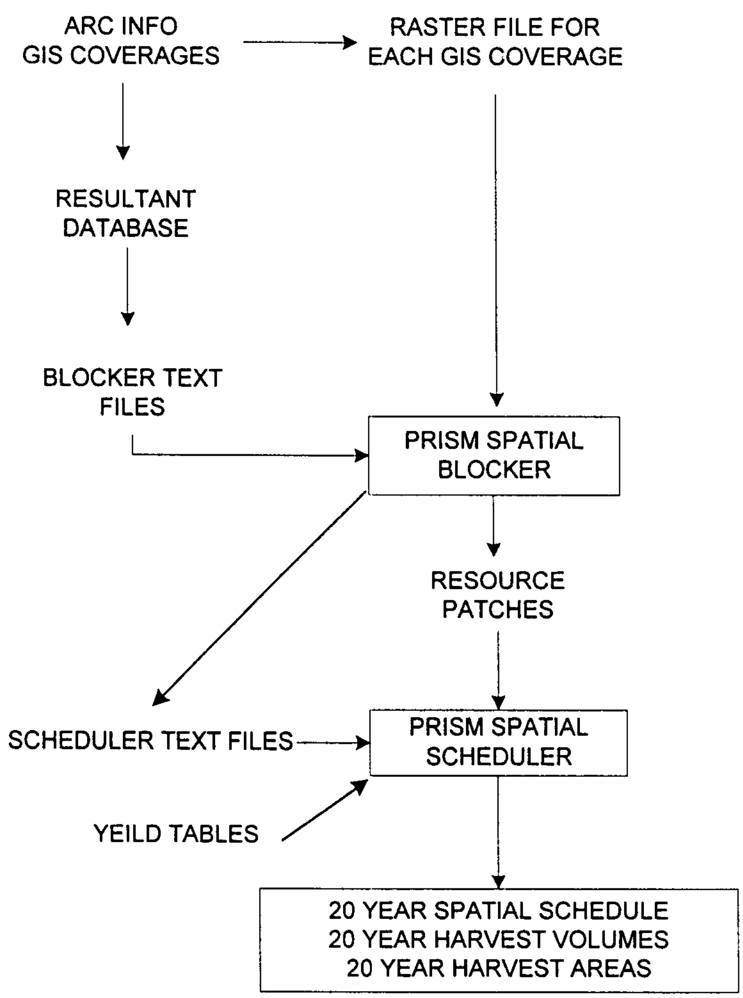
Reporting

PRISM output data describing every unit at any time period can be captured in a database. Tabular reports and maps can be produced from the database, which display information about the timber harvest and the state of the resource at any time.

DEVELOPING THE 20 YEAR PLAN

Figure 1 below diagrams the procedure used to develop the 20-year plan for TFL 55.

Figure 1: 20 Year Plan Procedure



ARC INFO Coverages

The following GIS coverages were used in the 20-year plan:

- forest cover
- development plan blocks
- landscape unit boundaries
- biogeoclimatic zone, subzone and variant
- caribou and ungulate habitat zones
- operability lines

Each coverage was rasterized to create input files for the PRISM SPATIAL BLOCKER.

Resultant Databases

A database was built from the resultants created when all the GIS coverages were overlaid. In this database each resultant constituted a separate record.

Blocker Text Files

A set of text files required as input by the PRISM spatial blocker were generated from the resultant database.

PRISM Spatial Blocker

The PRISM spatial blocker was run to produce a pattern of resource patches across the gross forest landbase. These patches accepted without alteration the blocks in the TFL 55 development plan and proposed salvage blocks. New patches were created by PRISM on the remaining forest landbase, according MAC based rules.

Scheduler Text Files

The PRISM spatial blocker also produced a text file describing the relevant resource attributes of each spatial patch or block, including those in the development plan. This file was then used directly as input into the PRISM spatial scheduler.

Yield Tables

Yield tables were prepared for each patch or block. Where a block contained parts of more than one forest cover polygon, a separate yield table was constructed for each part. Future block timber volumes were predicted by adding the results of the different yield tales for each part of the block.

PRISM Spatial Scheduler

The text output file from the blocker and the yield tables were used as input in the PRISM spatial scheduler. A 20-year harvest schedule was produced by PRISM according to MAC based constraints, using the results from the Forest Estate model timber supply analysis. The targets used for the 20-years of the Evans planned management or base run.

The 20-year plan did not include volumes expected from salvage logging because the objective is to test the results of the timber supply analysis without 'windfall volumes' that might come from salvage logging. The salvage logging blocks were recognized in terms of adjacency and green up, and in their effect on patch size distributions.

RESULTS

The 20-year plan confirmed the results of the timber supply analysis, current management option. The target volumes were successfully located while meeting adjacency and green-up rules. These volumes were achieved in addition to the volumes to be harvested from several salvage blocks.

Table 1: 20-year Plan Annual Harvests (cubic metres)

Year	Landscape Unit			Total	
	17	18	19	Actual	Actual Net*
1-5	70,214	159,185	225,206	454,605	449,655
6-10	87,849	45,765	320,409	454,022	449,072
11-15	47,563	72,742	289,412	409,717	404,767
16-20	65,622	218,790	125,068	409,480	404,530
Total	271,266	496,499	960,115	1,727,825	1,708,025

* Harvest volume excludes 990m3 losses per year

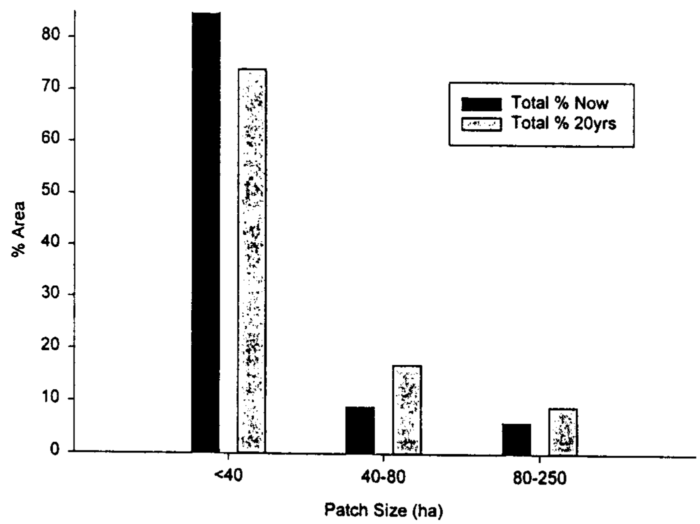
The volumes in table 1 leave wildlife tree patch volumes on the timber harvesting landscape.

Patch size distributions produced by PRISM were computer at the beginning and the end of the 20-year plan. These calculations included the salvage blocks. Table 2 and Figure 2 shows the result for the entire productive forest on TFL 55.

Table 2: TFL 55 Summary of Patch size distribution

Patch Size (ha)	% Now	% 20yrs	Guidebook
<40	85	74	30-40
40 – 80	9	17	30-40
80 – 250	6	9	20-40
Total	100	100	

Figure 2: Patch Size Distribution



For the TFL as a whole, the area in patches smaller than 40 hectares is expected to decrease over the next 20 years.

The results of the spatial model show that the areas in patches between 40 and 80 hectares and 80 and 250 hectares are expected to increase. These changes will move patch size distribution closer to the guidebook values shown in table 2. Similar changes are expected in the patch size distribution of the old seral stage. Figure 3 shows the results of the spatial model for the old seral stage.

Figure 3: Old Seral Stage: Patch Size Distribution

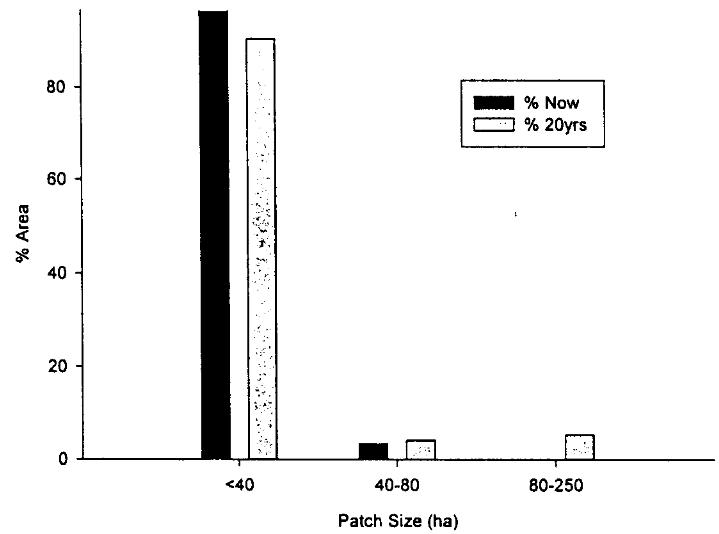


Table 3 below summarizes the areas of mature and old forest for the gross productive and timber harvesting land base.

Table 3: Areas of mature and Old Forest (hectares)

Year	Mature		Old	
	Productive	THLB	Productive	THLB
1-5	27,856	11,992	2,249	1,356
6-10	27,235	11,244	2,020	1,146
11-15	26,795	10,530	2,019	1,097
16-20	25,955	9,676	2,019	1,062

Note: Table shows the area at the end of period

In table 3 differences in area totals between the original polygon files and rasterized files due to the gridding and blocking processes in the spatial model have been reconciled by adjustments to the totals obtained from the raster files.

Appendix 1 is a spatial representation of the 20 year plan. This consists of a 1:75000 map and an acetate overlay at the same scale.

APPENDIX 1

Spatial Representation of 20 Year Plan