Timber Supply and Silviculture Investment in an Economic Context for Coastal British Columbia

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Timber Supply and Silviculture Investment in an Economic Context for Coastal British Columbia

by

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INTRODUCTION

> "**Economic Difficulties** - Forestry must be founded on economic principles and not upon sentiment in a country where it is a basic industry. It is the major prop of our civilization, not merely a contribution to aesthetic or recreational interests.
>
> The world price of timber is still regulated by the cost of production from virgin forests, and, although world resources of wild softwoods are rapidly diminishing, even after they have all gone British Columbia will still be at a disadvantage compared with countries which can produce cultivated timber nearer to large world markets. The geographic position which has delayed the exploitation of Pacific Coast virgin forests will also reduce the profit from its cultivated forests. Our province will still be 9,000 miles from competitive European markets.

Quote from:
Mulholland, F.D. 1937. The forest resources of British Columbia 1937. Department of Lands, British Columbia Forest Service, Victoria. 153 p

> "To vulgarize and oversimplify, there has been a tradition in forestry management which claims that the goal of good policy is to have sustained forest yield, or even "maximum sustained yield" somehow defined. And typically, economists have questioned this dogma."

Quote from:
Samuelson, P.A. 1976. Economics of forestry in an evolving society. *Economic Inquiry* Vol. XIV pp. 466-492.

The preceding quotes from Mulholland and Samuelson emphasize the underlying relevance of economic reality in the area of timber supply determination. They also point out that methods of its application are far from indisputable or trivial. Even so, the combined age of the quotes may be considered within the range of a rotation age, and in that time there are few studies in Canada that have attempted to empiricize some of the most fundamental relationships between economics and timber supply[1]. Like Mulholland and Samuelson, others have emphasized the importance of economic relationships in

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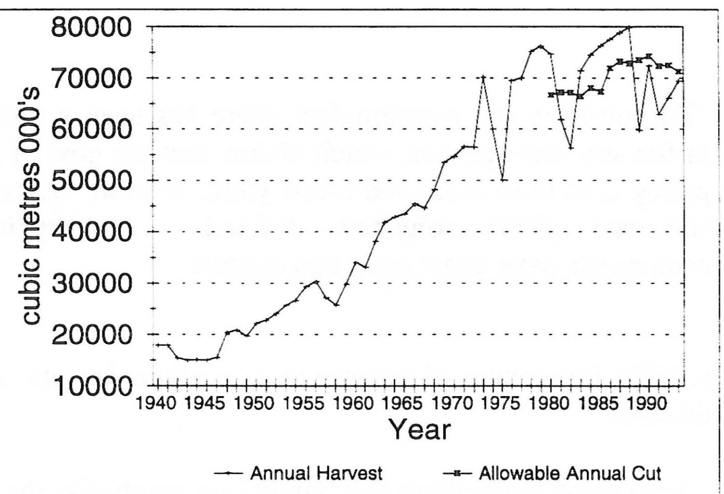
[1] See Marshall (1990) Williams et al. (1984) and Beck et al. (1987).

timber supply determination both from an operational and a policy perspective. However actual estimates of economic timber supplies for Canada are few. Economic availability and demand have always determined the rate of harvest, yet methods for determining timber supply remain essentially biologically based and have predominated as such in British Columbia since Sloan (1945).

One of the seminal studies of economic timber supply determination in British Columbia was performed by Williams and Gasson (1986). One of their projections using very pessimistic assumptions of future real price increases suggested that there was only about 17 years of harvest left on Crown land in the Coastal region. This rather startling observation, although based on some very interesting assumptions, was perhaps the first empirical evidence that timber supply can be highly price elastic, regardless of the direction of price movements.

A more obvious piece of empirical evidence that helps to illustrate harvest levels as more a function of economic forces (i.e. the demand for timber) is a comparison of historical harvest levels and estimates of more sustainable harvest levels in Figure 1. Until about 1970, harvest levels were always well below estimates of biologically sustainable harvest level. It has only been in the past couple decades that demands have become close to current estimates of biological sustainability.

Figure 1: Allowable Annual Cut and Annual Harvest in British Columbia



Source: B.C. Ministry of Forests Annual Reports - for years prior to 1980 harvest may or may not be from lands for which an AAC was calculated.

Figure 1 may suggest that estimates of sustainable harvest levels do not even begin to consider economic availability, yet historical evidence suggests that this is also not true. It is more the case that where economic availability is considered, it is only at a very general level, and provides only a point estimate of economic availability. This is in contrast to fact that the biologically sustainable harvest level by definition is what is considered sustainable over more than one rotation.[2]

Williams (1993) discusses the potential implications of not considering changes in economic availability in both short and long term timber supply determination, and provides empirical estimates of potential opportunity costs. These costs would be born by both the Crown and industry and for the nine Coastal TSAs examined could be as high as $47 million per year (Williams 1993).

Another aspect of economic timber supply is the impact of current investments in maintaining a sustainable timber supply on present and future values. In addition to expenditures for silvicultural activities by industry, the B.C. Ministry of Forests currently spends approximately $20 million dollars annually on silviculture on the Coast[3]. The allocation of these dollars is primarily driven by the demands of the pre-harvest silviculture prescriptions, but beyond stand-level prescriptions, there appears to be no objective mechanism for measuring the economic efficiency of all expenditures. Research has been conducted in recent years to provide methods to answer some of the efficiency questions for specific areas, but the range of expenditures in a budget are not judged concurrently for a given region, or in light of their relative contribution to economic timber supply at the margin. The B.C. Ministry of Forests, Silviculture Branch, in conjunction with other researchers over the past few years has worked toward remedying this situation. A number of studies have been produced to assess the economically efficient allocation of silviculture budgets for specific forest regions to meet timber supply objectives.[4] Yet for the most part, these studies neglect to address the question of efficiency, which is necessary to determine the allocation of silvicultural expenditure that more closely satisfies the demands for timber, or conversely, the opportunity costs of not meeting them.

There is a perception that the addition of empirical economic analysis to the timber supply determination process would somehow adversely compromise the goals of maintaining biologically sustainable timber supplies. In most cases this is unwarranted, as resource economics literature since at least the early 1960's has been foremost in advocating conservation and "wise use" as highly desirable goals of natural resource use policies. Many advocates have stated that there is usually ample economic justification

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[2] The B.C. Ministry of Forests in their current Timber Supply Review Process, uses a process of "netting down" the land base to exclude areas that are currently not considered economically available for the estimate of long term timber supply. These estimates are not the final determination of long term timber supply, rather part of a series of recommendations to the Chief Forester. See B.C. Ministry of Forests (1991) for a description of this process.

[3] Throughout this document the terms "Coast" and "Coastal" refer to the area of Crown forest land within these nine TSAs: Midcoast, Northcoast, Queen Charlotte, Sunshine, Kingcome, Soo, Arrowsmith, Strathcona, and Fraser

[4] See for example Simons (1992), Sterling Wood Group (1993), Reid Collins (1993)

for "sustainability" as it contributes value to the overall social welfare function.[5] One of the greatest challenges in any natural resource field has been implementation of these policies, keeping efficiency goals in mind as well.

This report attempts to fill some of the voids in both empirical information and methodology for examining the economic dimensions of Coastal B.C. timber supply. A model and associated database of nine Coastal Timber Supply Areas (TSAs)[6] are presented along with simulation results from eight timber supply Scenario projections. The model used is called the Price Responsive Timber Supply Model (PRTSM) version 7.2. Earlier versions of PRTSM were developed by Cortex Consultants under contract to the Policy and Economics Directorate of the Canadian Forest Service in Ottawa.[7] The original Coast database was also compiled by Cortex under the same contract, along with some preliminary analyses. This report builds on this earlier work with modifications to the model, and enhancements to assumptions used in the Scenarios.

Part one of the report contains a brief description of the unique characteristics of the PRTSM. Part two details the original sources of the database, and methods used in running the eight Scenarios. Part three provides description and interpretation of results, and in part four, further discussion of results and conclusions is presented. Appendix I and Appendix II contains detailed model input and output.

PART ONE

The Price Responsive Timber Supply Model

The PRTSM[8] is a simulation model that requires a number of exogenous inputs. These inputs are combined with a biological representation of the forest, and they include:

- Prices - volume-weighted log prices by species and diameter class
- Discount rate - or real interest rate used to determine soil expectation value
- Allowable Annual Harvest Schedule or AAC - The PRTSM is based on the idea that AAC is determined as a Government policy decision, and that the market determines

5 See for example Scott (1955), Solow (1986), or Scott and Pearse (1989)

6 A Timber Supply Area in British Columbia is an area of public land established in accordance with Section 6 of the *Forest Act*

7 More information on PRTSM can be obtained from Cortex Consultants, #11 Brooks Road, Halfmoon Bay, B.C., V0N 1Y0 (604) 885-9699 or from other literature cited in this report

8 For a more detailed description of the PRTSM see Messmer et al. (1993) and Williams (1991)

how much will be harvested. If a suitable AAC harvest schedule is unavailable for a given analysis, the PRTSM can be set to calculate one, but for this analysis, AAC schedules are exogenous

- Real annual price change The overall projected real increase in the price level for delivered roundwood, over and above inflation

- A budget constraint for silviculture expenditures - The PRTSM recognizes four general categories of silviculture expenditure in three different units of measure: total dollars, total person-years and total hectares treated.

Although there are a number of other exogenous "shocks" that can be administered to a particular analysis, the above lists the main variables that can be adjusted in conducting sensitivity analyses with the PRTSM.

There are two primary functions performed by the PRTSM in determining the economic sensitivity of a timber supply:

1. The forest inventory represented in a PRTSM database is identical to virtually every other timber supply or inventory projection model. The major difference is that in every projection period, all of the inventory is appraised to determine whether or not it contributes to the timber supply land base. The land base actually deemed available for harvesting is a function of current and projected market conditions. The forest growing stock defined in the model must pass soil expectation value (SEV) tests each period. This test is simply whether or not the area in each analysis unit at each ageclass has an SEV greater than or equal to zero. If the SEV is less than zero the land base in question does not contribute to the long term timber supply land base. As will be seen in the results, the amount of land base contributing to the long term timber supply land base can vary considerably among future periods.

2. Based on the exogenously determined schedule and the differences between prices and costs within each period, a harvest level is removed from the inventory each period. The exogenous harvest level is adjusted according to the rule that $\pm 10\%$ of the scheduled harvest level can be harvested over the five year period [9]. This allows some flexibility for the PRTSM to adjust harvest levels in each period when there may be insufficient operable timber. If costs are greater than price for more timber than what is required from the schedule, then only the amount that is actually operable is removed from the inventory as harvest. Conversely, if more timber is economically operable that what the schedule asks for, the amount scheduled and removed as harvested can be increased by up to ten percent in each five year period.

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[9] This "cut control rule" is an attempt to mimic current cut control policy that specifies a harvest target of $\pm 10\%$ of the AAC over a pre-defined five year period Both the upper and lower bounds of these numbers can be adjusted in the PRTSM input.

The output in point 1 above is referred to as the economic long run sustainable yield, or economic LRSY. The output in the point 2 is referred to as the economically operable AAC. Both of these measures are determined over a range of price index within each period to determine their relative sensitivity to price. This output is then graphed to illustrate the shape of projected supply curves.

Another feature of the PRTSM is its ability to implement silvicultural activities. The silviculture component of the PRTSM was derived from the "British Columbia Silviculture Planning Model" by Phelps et al. (1991)[10]. It is essentially an accounting and budget allocation procedure, whereby harvested area is treated according to the schedule defined in an input file, subject to a user-defined budget constraint.. Even though the input is relatively aggregate, there is quite alot of detailed required to define the silviculture plan. This includes:

- Costs of all treatments - Dollar per hectare costs of each of the four categories of treatments; Basic, Planted, Backlog regeneration and Spacing. These can be unique for each analysis unit.

- Area harvested from one analysis unit may be redefined to regenerate according to the definitions of another analysis unit. This is analogous to the "Model II" feature of most LP harvest scheduling models.

- Discrete probability distributions of success and regeneration lag are defined for each analysis unit/treatment combination except for spacing, which does not involve a change in the age of the area spaced.

- A budget constraint must be defined for the five year period length. Expenditures in dollars, person-years, and area treated are set, and allocated according to an index number of priority assigned to each analysis unit/treatment possibility. The budget levels can be made non-constraining by assigning a "-1" in the amount input field. With no budget constraint, the PRTSM will treat as much area as is harvested in each period, according to the index numbers of priority.

An important concept used in defining the economic dimensions of timber supply is the idea of a trade-off between an intensive margin and an extensive margin. The intensive margin refers to the timber production possibilities on a fixed area of forest land, given costs and prices for silviculture investments and their outputs. The extensive margin refers to the extent of the total forest land base that falls within economic operability, given pre-defined production possibilities and values. Both of these margins are

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10 See: Phelps, S.E., Thompson, W.A., Webb, T.M., McNamee, P.J., Tait, D., and C.J. Walters. 1991. British Columbia Silviculture Planning Model User's Manual. Report for the B.C. Ministry of Forests. Also: Cortex Consultants, Inc. 1992. Assessment of the Silviculture Planning Model. Submitted to British Columbia Ministry of Forests Economics and Trade Branch.

determined in the PRTSM and are measured in several ways in the output. The extensive margin is simply the percent of the total area of forest that is economically operable at a given point in time, and the intensive margin can be measured as possible levels of timber output in a given time period as a function of different silviculture budget levels, and/or price projections. In reality, both the intensive and extensive margins are affected simultaneously, and this is reflected in the PRTSM as both margins are affected by the same change in one input(e.g. real annual price change).

PART TWO

Methods and Data Sources

The original B.C. Coast PRTSM data set was compiled by Cortex Consultants[11] from a number of secondary sources. These include:

- The B.C. Ministry of Forests 1989 Forest Inventory of the AAC land base for 9 TSAs: Midcoast, Northcoast, Queen Charlotte Islands, Sunshine, Kingcome, Soo, Arrowsmith, Strathcona and Fraser

- Slope and operability distributions, and haul distances, as compiled by Morrison et al. (1985) and Morrison and Wilamovsky (1987)

- AACs, and land bases for each TSA - various dates from 1981-1990, all originally from the B.C. Ministry of Forests, as compiled by Cortex Consultants.

- Cost of recovery from stump to mill, mostly from the B.C. Ministry of Forests "Coast Appraisal Manual" and other sources from Cortex Consultants. These are functions of slope, operability, haul distance, species group, diameter class and age

- Yield curves for second growth were modified to reflect silvicultural treatments where applicable. These modifications can be made efficiently in the PRTSM with the definition of curve "shifters" or multupliers.

In constructing any PRTSM data set, the primary objective is to define the number and kind of aggregates of forest into analysis units. The analysis units are defined as aggregates of forest land base that have similar cost, value and yield characteristics.

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11 For a complete description of the methods involved in creating the B.C. Coast PRTSM data set see "PRTSM Analysis Unit Generator B.C. Coast" by Cortex Consultants, December 1992, submitted to Policy and Economics Directorate, Canadian Forest Service, Ottawa. Descriptions for the creation of other PRTSM data sets can be found in Messmer and Booth (1992) and Messmer and Booth (1993).

The Coast data set consists of 23 analysis units, each represented with its own set of cost, value, and yield curves, and its own set of silviculture responses and conditions. Regenerated or second-growth forest land is represented by a further 42 analysis units.

Table 1 on the following page provides a summary of the eight Scenarios that were run for the analysis. For each Scenario a set of exogenous conditions were set. These include a silviculture budget, a harvest schedule, a projection of annual real price change, a discount rate, and a discrete 20% first period price shock variable (yes or no).

The price shock is incorporated in that the value of all timber in the first period is increased by 20%. This was thought to help reflect current real price changes that have recently occurred in the solid wood products sector (see Prins 1993).

Choosing a real discount rate is often the subject of considerable debate. Heaps and Pratt (1989) provide useful guidelines for choosing an appropriate rate. Only two were chosen for the analysis either 2.5% or 4%. The discount rate is used to determine both the economic rotation age, and the soil expectation value in the land base appraisal.

Table 1: B.C. Coast TSAs PRTSM Scenarios

	Basic Expenditure million $ per year	Incremental Expenditure million $ per year	Backlog Expenditure million $ per year	Harvest Schedule* million m^3	Real Annual Price Change %	Discount Rate % annual	20% 1st per. price shock
Scenario 1	10.0	2.0	8.0	10.46 to 7.78	0.0	4.0	No
Scenario 2	10.0	2.0	8.0	10.46 to 7.78	0.3	4.0	No
Scenario 3	10.0	2.0	8.0	10.46 to 7.78	1.0	4.0	Yes
Scenario 4	10.0	2.0	8.0	10.46 to 7.78	1.0	2.5	Yes
Scenario 5	Unconstrained	Unconstrained	Unconstrained	10.46 to 7.78	0.5	2.5	Yes
Scenario 6	Unconstrained	Unconstrained	Unconstrained	10.46 to 7.78	0.5	4.0	Yes
Scenario 7	Unconstrained	Unconstrained	Unconstrained	7.5	0.5	4.0	Yes
Scenario 8	12.0	8.0	10.0	7.5	1.0	4.0	Yes

***NOTE:** Harvest Schedules for Scenarios 1 to 6 started at 10.46 million m^3 per year and dropped to 7.78 million m^3 over the first twenty years. Harvest schedules for Scenarios 7 and 8 were 7.5 million m^3 per year over the entire simulation period.

The harvest schedules used were compiled from estimates of AAC and LRSY determined by the B.C. Ministry of Forests for each TSA for various years from 1981-1990. Scenarios 1 to 6 begin with higher level AACs in the first twenty years, and then drop to a long term harvest level over the rest of the 65 year simulation period. Scenarios 7 and 8 use a constant harvest level throughout the simulation period that is closer to the long term harvest level suggested by the schedule. As previously mentioned, the PRTSM removes growing stock in the form of a harvest according to the schedule each period. If, within a period there is more timber available than the schedule requires, then harvest is increased by up to 10% per 5-year period. If less timber is operable in a period than is scheduled, then the next period's harvest level is dropped by 10%, and the actual harvest in that period is only what is operable. Operable timber for harvesting is simply that timber where price is greater than or equal to the delivered wood cost in a given period. Within-period operability for harvesting is **not** determined by soil expectation value, though the two are highly correlated.

The real annual price change represents the average real percent price increase for all roundwood in B.C.. Studies of historical real price changes for roundwood in B.C. and North America have been found to be consistently in the range of 0.1 to 1 percent per year over about the last hundred years (See Sedjo and Lyon (1990) and Simons and Cortex (1992)) The rates used in the analysis were 0, 0.3, 0.5, and 1 percent per year. In addition within each period, the version of PRTSM used (version 7.2) adjusts the range of price index **within** each period. This is used to calculate the LRSY and AAC supply curves by the annual real price change. Previous versions of the PRTSM did not have this feature. The range of price index used to determine LRSY or operable AAC is from 0.55 to 2.5 at increments of 0.5. In Scenarios that have a non-zero real annual price change, this index is adjusted by the compound annual real price change in each projected period.

Silviculture budget levels were chosen for each Scenario. Budget levels for Scenarios 1 to 4 were identical to each other. Scenarios 5 to 7 did not have silvicultural budget constraints, therefore the amounts actually spent on treatments for not sufficiently restocked areas (Backlog NSR) or treating harvested areas was determined by how much of these areas existed in each period. Scenario 8 had the largest constrained budget. The levels chosen for these budgets is somewhat approximate, but they appear consistent with recent B.C. Ministry of Forests silviculture expenditures for the Coast.[12]

Part of the silviculture input file for Scenario 5 is shown in Table 2. Silviculture budget levels in Table 2 appear in the last section entitled "budget". The levels for Scenario 5 are unconstrained, so they appear as -1. The rest of Table 2 defines the schedule of potential treatments for each analysis unit. The numbers in each row under the Regen lag and NSR Backlog sections are percent distributions applied to the treated area. For example if in a given period, 100 hectares from analysis unit 1 were planted, it would regenerate into analysis unit 24. The cost would be $558 per hectare and it would require 4.5 person

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[12] See "Silviculture Programs, March 31, 1993 Review" and "Forest Renewal Plan Year End Review 91/92", B.C. M.o.F. Silviculture Branch.

days per hectare. Of the 100 hectares planted, 44% would regenerate immediately, 28% with a five year regeneration lag , and 28% with a 10 year regeneration lag. If 100 hectares from analysis unit 1 regenerated naturally (i.e. no treatment), it would regenerate back into analysis unit 1. The cost would be $0 per hectare and it would require 0 person days per hectare. Of the 100 hectares planted, 1% would regenerate immediately, 2.5% with a five year regeneration lag , 2.5% with a 10 year regeneration lag, 43.5% with a 15 year regeneration lag, 43.5% with a 20 year regeneration lag, and 7% would revert to backlog NSR. The 7% that reverts to Backlog NSR is treated according to the Backlog section in Table 5. For the B.C. Coast Scenarios it was assumed that Backlog NSR was planted, according to the costs, and percent successes in the Backlog section of Table 2. In Table 2 this appears as:

```
---------------------------------------------------------------------------------------------------------------
Analysis Unit  Cost  Labor     |-- Growth Type --|----- Regen Lag ----|-- NSR -| -- Analysis Unit Name -- | Treatment |
  Cut Regen    $/ha  pd/ha Pri   Nat    Plt    Enh    5     10     15     20   Backlog
---------------------------------------------------------------------------------------------------------------
No Treatment
    1    1       0.0  0.0    0  1.     .      .     2.5    2.5  43.5  43.5   7.0    1   North Ced/Cyp G,M     Natural
```

The spacing section of the silviculture plan in Table 2 allows for planted areas to be subsequently spaced. For example the first row of the spacing section says that area planted according to the definition of analysis unit 24 become analysis unit 45 after spacing. The spacing costs $833 per hectare, and requires 4 person-days per hectare to perform. It has an index of priority of 23 which is relatively high, and any area in analysis unit 24 to be spaced must be at least 13 years old. As with other activities, the amount of spacing that occurs is a function of the amount of budget allocated to spacing. In Table 2 this appears as:

```
Spacing
   24   45      833.   4.0   23   13.
```

There are two main functions that the PRTSM performs to account for the biological effects of silviculture treatments. The first is subsequent to harvesting, an area is re-defined to a different analysis unit with different yield, cost and value curves. The second function is applying the relative distribution of regeneration lags specified in the silviculture plan file (in Table 2).

Table 2: Part of the Silviculture Input File for B.C. Coast Scenario 5

Silviculture Plan B.C.Coast Scenario 5 Unconstrained Budget

Analysis Unit Cut	Regen	Cost $/ha	Labor pd/ha	Pri	Growth Type Nat	Plt	Enh	Regen Lag 5	10	15	20	NSR Backlog	Analysis Unit Name		Treatment
No Treatment															
1	1	0.0	0.0	0	1.	.	.	2.5	2.5	43.5	43.5	7.0	1	North Ced/Cyp G,M	Natural
2	2	0.0	0.0	0	1.	.	.	2.5	2.5	43.5	43.5	7.0	2	North Ced/Cyp P,L	Natural
3	3	0.0	0.0	0	1.	.	.	2.75	2.75	39.75	39.75	14.0	3	North Hem/Bal G	Natural
4	4	0.0	0.0	0	1.	.	.	2.75	2.75	39.75	39.75	14.0	4	North Hem/Bal M	Natural
5	5	0.0	0.0	0	1.	.	.	2.75	2.75	39.75	39.75	14.0	5	North Hem/Bal P,L	Natural
Planting															
1	24	558.	4.5	7	.	44.	.	28.	28.	.	.	.	1	North Ced/Cyp G,M	Natural
2	25	333.	2.5	3	.	44.	.	28.	28.	.	.	.	2	North Ced/Cyp P,L	Natural
3	26	410.	3.3	7	.	44.	.	28.	28.	.	.	.	3	North Hem/Bal G	Natural
4	27	278.	2.2	6	.	44.	.	28.	28.	.	.	.	4	North Hem/Bal M	Natural
5	28	371.	1.4	3	.	44.	.	28.	28.	.	.	.	5	North Hem/Bal P,L	Natural
Backlog															
1	24	1695.0	5.7	7	.	90.	.	.	.	4.5	4.5	1.	1	North Ced/Cyp G,M	Natural
2	25	1163.0	3.4	3	.	90.	.	.	.	4.5	4.5	1.	2	North Ced/Cyp P,L	Natural
3	26	1352.0	4.0	7	.	90.	.	.	.	4.5	4.5	1.	3	North Hem/Bal G	Natural
4	27	1113.0	3.3	6	.	90.	.	.	.	4.5	4.5	1.	4	North Hem/Bal M	Natural
5	28	1308.0	2.1	3	.	90.	.	.	.	4.5	4.5	1.	5	North Hem/Bal P,L	Natural
Spacing															
24	45	833.	4.0	23	13.										
25	46	833.	4.0	9	13.										
26	47	670.	3.1	52	13.										

Budget

	$	person-days	thousands of hectares
Planting	-1.0	-1.0	-1.0
Backlog	-1.0	-1.0	-1.0
Spacing	-1.0	-1.0	-1.0

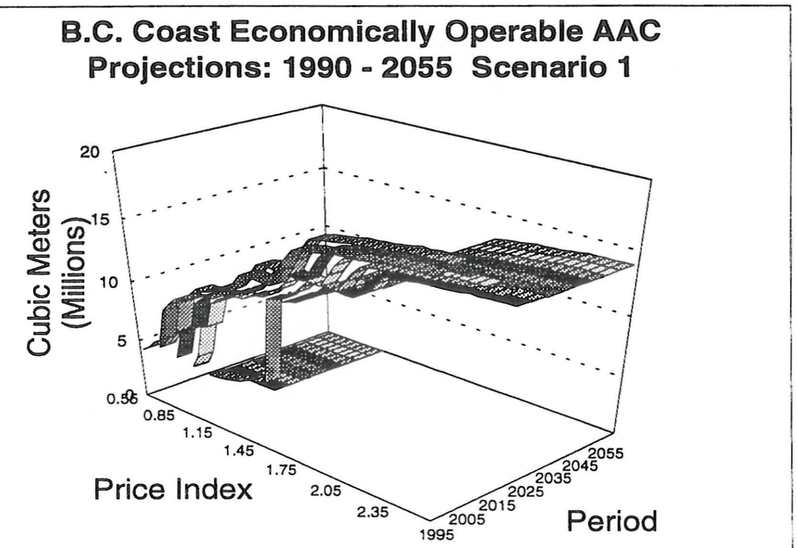
The PRTSM produces eight different output reports in an ASCII text format, which can be readily imported in spreadsheet, word processing or graphics software to produce a variety of reports and graphics. The amount of output in four of the eight reports can be controlled by specifying in the input, the exact future periods output is required for. A complete explanation of the PRTSM input file and output reports can be found in Messmer et al. (1993).

Part Three

Results and Discussion

The output generated from eight separate PRTSM runs is quite extensive. The bulk the output from this analysis can be found in Appendix I and Appendix II. The following results focus on illustrating the relative sensitivities of timber supply to the variables outlined in Table 1.

Figure 2: Economically Operable AAC Projections - Scenario 1



Figures 2 through 9 present economically operable AAC projections for each of the eight Scenarios. For each five year period in the PRTSM simulation, estimates of operable AAC are determined across indices of price. The price index is developed as a volume weighted average of all prices for each analysis unit, such that the overall average is equal to 1.0. These curves can be defined as the AAC supply curves, or how much of the exogenously scheduled AAC is available over time and within each period at different price levels. The all share the same general shape. At very low price levels, little if any AAC is considered economically operable. In the mid-range, they tend to be quite elastic (i.e. a relatively small change in price can result in a very large change in what is considered economically operable), and as price continues to increase, they become inelastic (unresponsive to price change) as ultimately AAC is constrained by both the schedule itself (no more than a 10% increase in AAC allowed per period) and the physical growth capabilities of the land base.

Figure 3: Economically Operable AAC Projections - Scenario 2

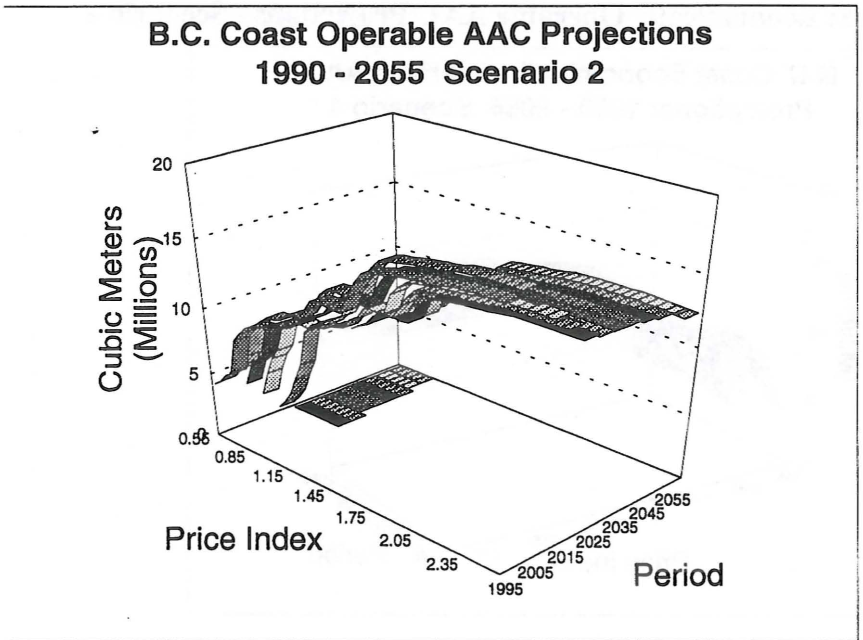


Figure 4: Economically Operable AAC Projections - Scenario 3

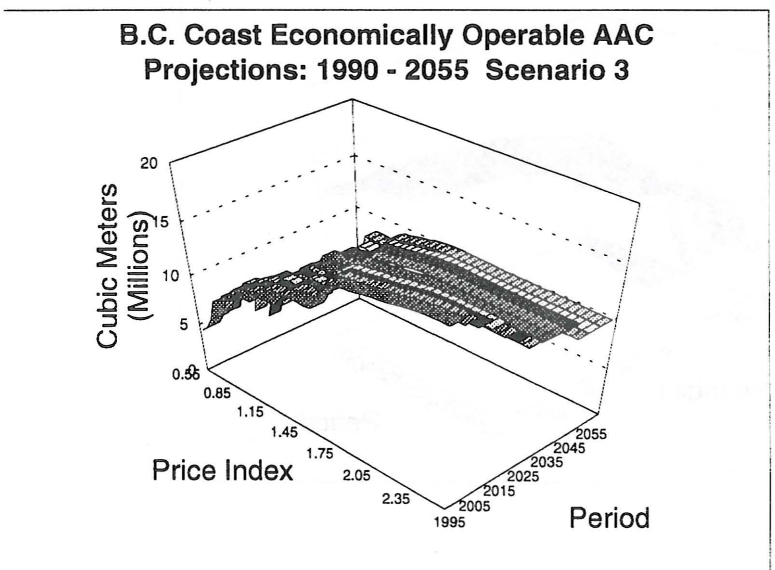


Figure 5: Economically Operable AAC Projections - Scenario 4

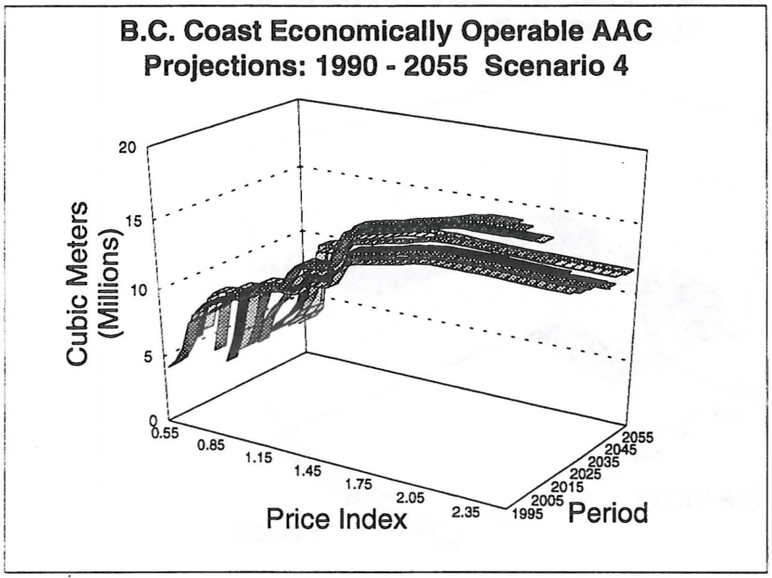


Figure 6: Economically Operable AAC Projections - Scenario 6

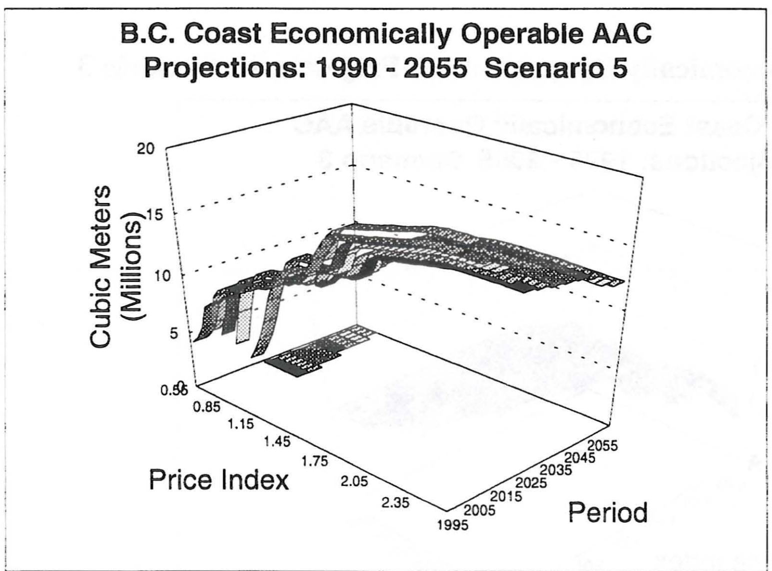


Figure 7: Economically Operable AAC Projections - Scenario 6

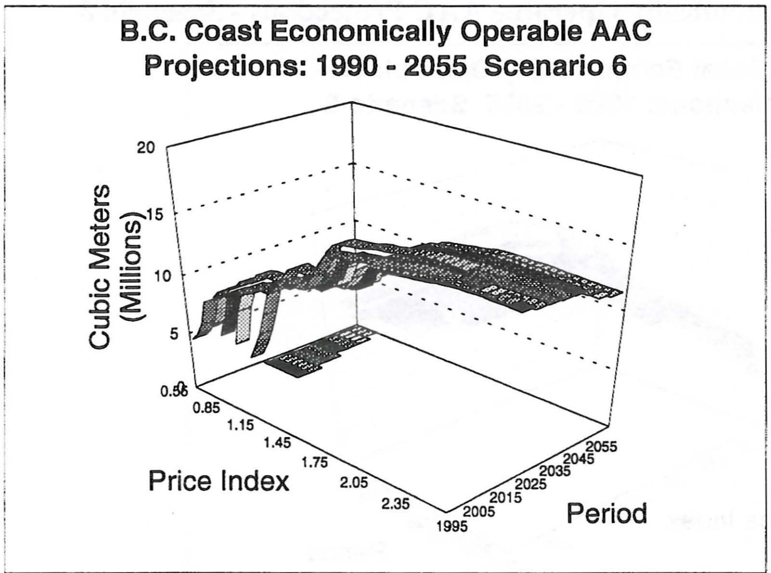


Figure 8: Economically Operable AAC Projections - Scenario 7

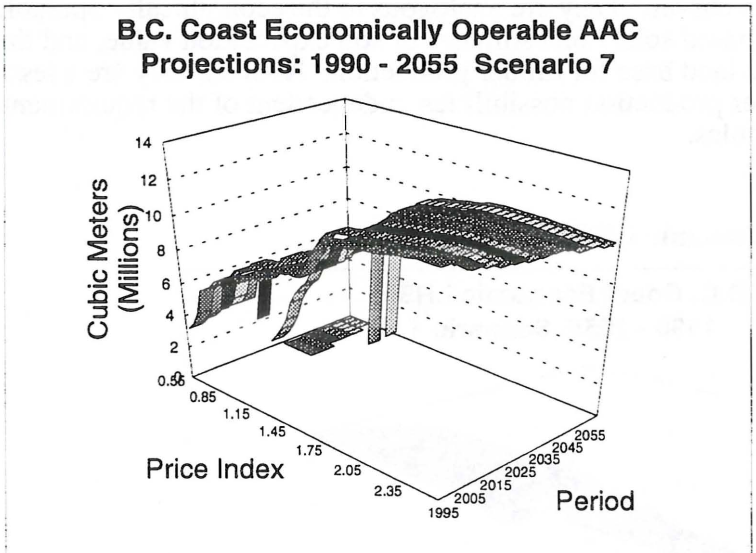
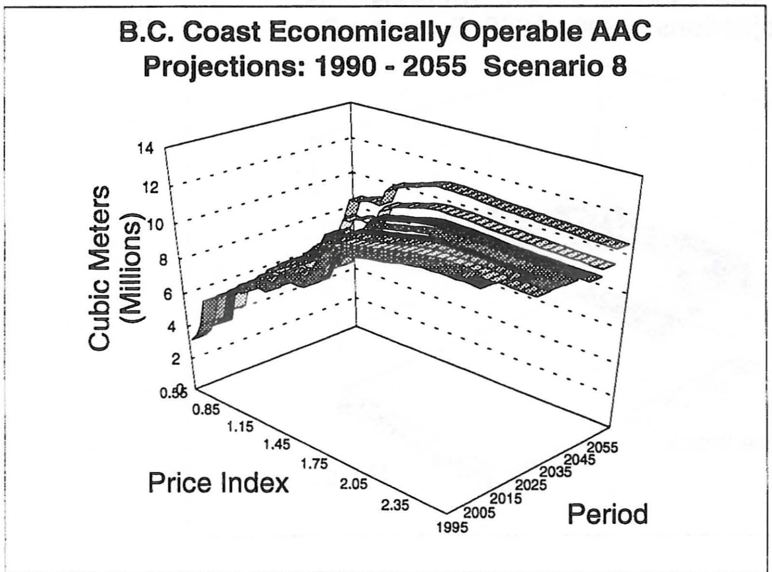


Figure 9: Economically Operable AAC Projections - Scenario 8



The same pattern can be seen in Figures 10 through 18. These Figures present the economic LRSY supply curves. They are analogous to the economically operable AAC curves except they are based solely on estimates of soil expectation value, and the physical capacity of the land base for timber production. As such, they are a less restricted view of timber production possibilities, independent of the requirements of pre-determined AAC schedules.

Figure 10: Economic LRSY - Scenario 1

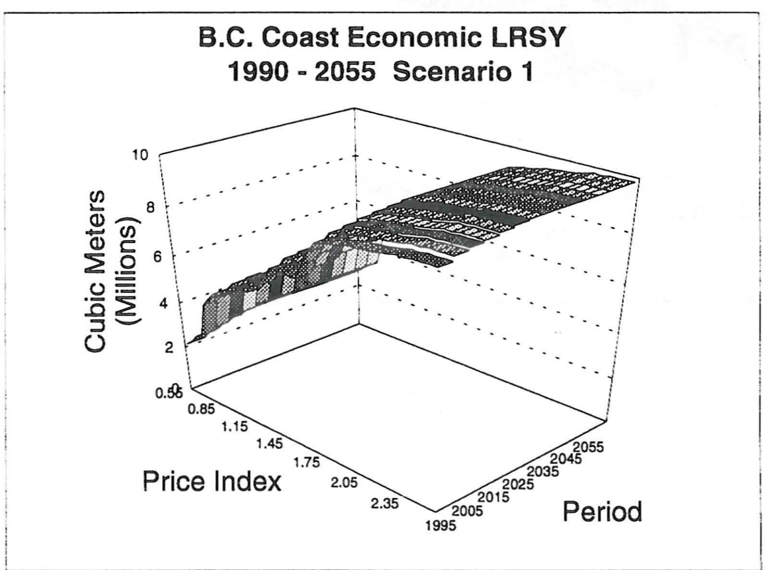


Figure 11: Economic LRSY - Scenario 2

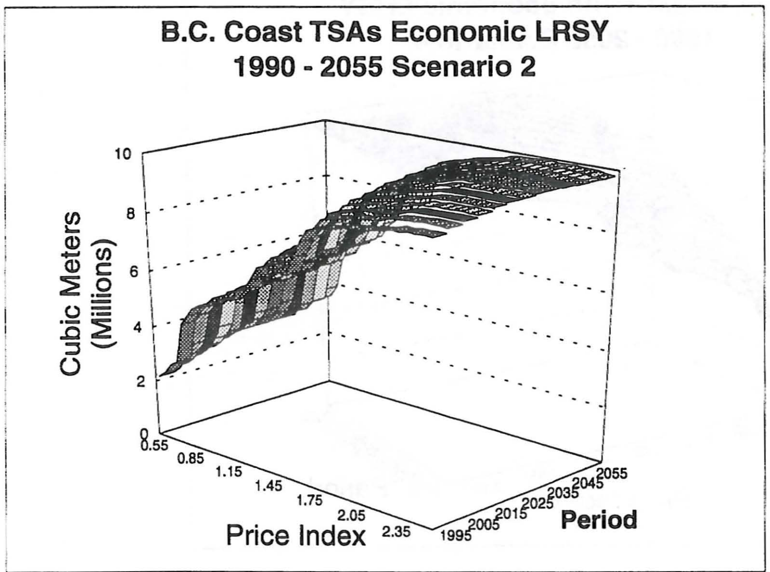


Figure 12: Economic LRSY - Scenario 3

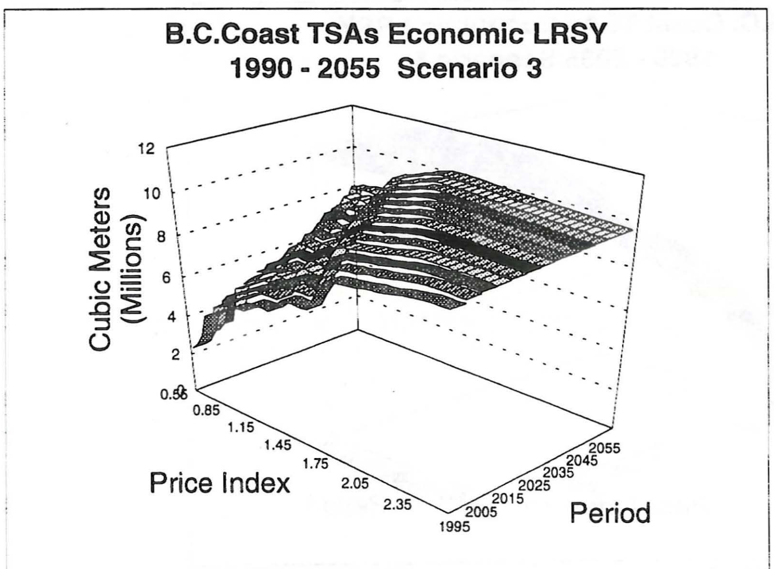


Figure 13: Economic LRSY Scenario 4

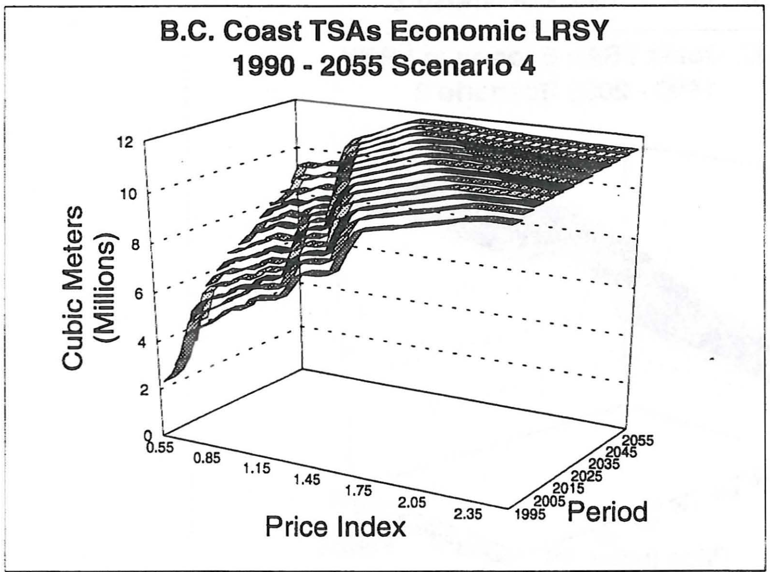


Figure 14: Economic LRSY - Scenario 5

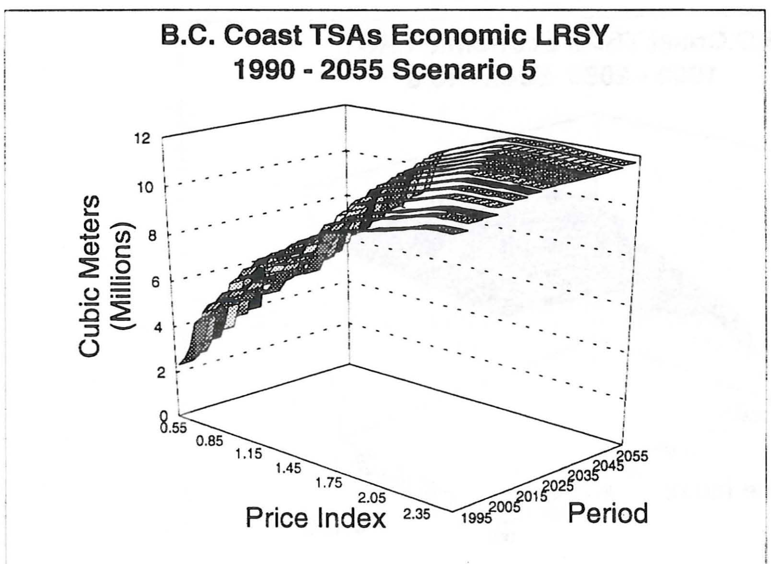


Figure 15: Economic LRSY - Scenario 6

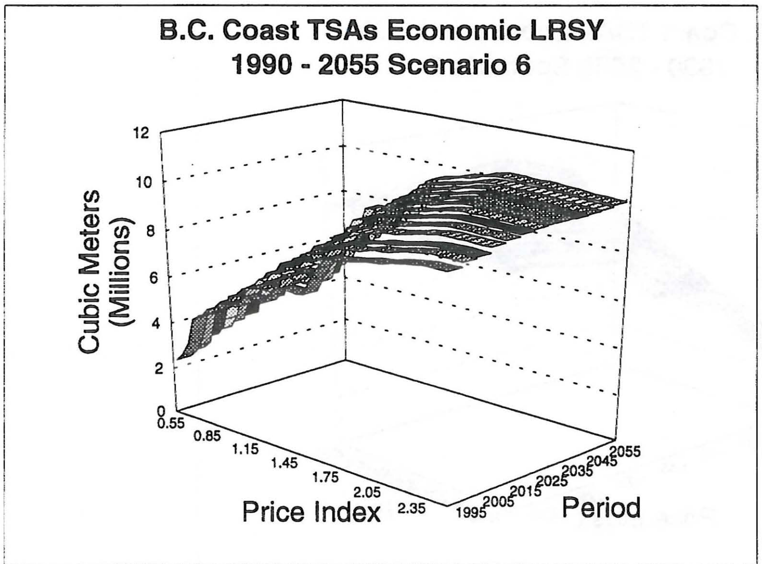


Figure 16: Economic LRSY - Scenario 7

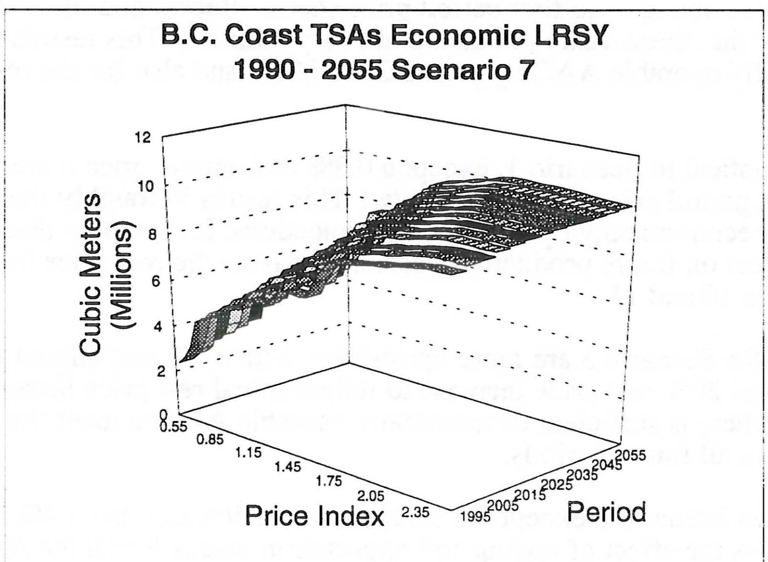
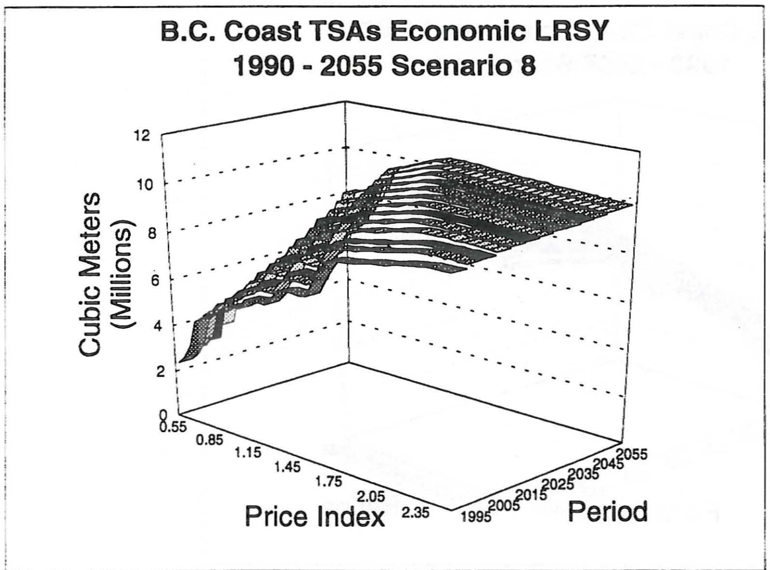


Figure 17: Economic LRSY - Scenario 8



Figures 2 and 10 illustrate the output from Scenario 1. In Scenario 1 there is no projected increase in the price level, and also no first period price shock. Recent and historical evidence would suggest that these assumptions are not very realistic. This results in a total lack of economically operable AAC by period 2010-2015, and also for the rest of the projection.

Scenario 2 is almost identical to Scenario 1, except a 0.3% real annual price increase is added, however no first period price shock is included. This results in roughly the same pattern which exists for economically operable AAC projections, It is evident that there is definitely a positive effect on future production possibilities from the real price increase when comparing Figures 10 and 11.

The price expectations for Scenario 3 are more optimistic; with a 1% real annual price increase and a first period 20% real price increase to reflect actual real price increases since 1990. As a result there is sufficient economically operable AAC to meet the schedule requirements in all future periods.

Scenario 4 is the same as Scenario 3 except the discount rate is lowered from 4% to 2.5%. A lower discount rate has the effect of raising soil expectation values for all the forest land base. This increases the economically operable land base, and the LRSY in future periods. Changes in the discount rate appear to have little effect on harvest levels in the current period, since area brought into the economic LRSY land base may not be old enough to harvest for a number of decades. This may be further enhanced by the fact that a lower discount rate tends to lengthen the economic rotation age, as it lowers the opportunity cost of capital (the forest growing stock). Under certain conditions more growing stock would imply a higher economic LRSY[13]

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[13] See Binkely (1993) for a complete explanation of the effects of rotation length and interest rates on the characteristics of timber supply curves.

Throughout this analysis, silviculture costs are not included in the total delivered wood cost used to calculate soil expectation values. As the land base is crown land, current policy does not dictate that the level or type of treatment be a function of an NPV or SEV test or further that any silvicultural treatment necessarily contribute value at the margin. Current policy does, however, dictate minimum standards to be achieved when harvested lands are regenerated, and whether or not the Crown or industry pays, depending on the type of tenure, and when the harvesting took place[14].

The budget constraint levels for silviculture are released in Scenario 5, and a 0.5% real annual price change is used. Otherwise, Scenario 5 is the same as Scenario 4. Comparing Scenarios 4 and 5 illustrates an important relationship between price expectations and silviculture expenditures. Unconstrained silviculture spending in the absence of high future price expectations will not in and of itself lead to enhanced future production possibilities. The reason for this is that more wood is generally still available with a constrained silviculture budget at all possible price levels (Scenario 4). This is evident when comparing Scenarios 4 and 5 where the slopes of curves in Figures 6 and 14 are steeper than in Figures 5 and 13. This result is even more significant in light of the fact that it is assumed that silviculture is a “cost of doing business”, and not an investment. It is likely that were it treated as an investment the result would be even more pronounced. Including establishment costs as an investment would ensure that less land base will be considered economically operable, unless future prices were high enough to justify such spending.

Scenario 6 is exactly the same as Scenario 5 except the discount rate was raised from 2.5% to 4%. The change in discount rate between the two Scenarios has basically the same result as the discount rate change between Scenarios 3 and 4. The higher discount rate in Scenario 6 results in lower timber supply production possibilities, but does not significantly alter current harvest levels. The higher discount rate is consistent with the notion of a higher opportunity cost of capital.

The scheduled harvest in Scenario 7 is substantially lower than the previous six Scenarios. Rather than a declining harvest level to some lower long term level, an equivalent amount is harvested each period. This amount is closer to the previous long term level of about 7.5 million m^3 per year. In spite of unconstrained silviculture spending, a future deficit of economically operable AAC is projected for at least a few periods, yet it is the least severe deficit projected, compared to deficits projected in Scenarios 1,2,5, and 6. Apparently, the limiting factor in Scenario 7 is the projected real price increase of 0.5%. This can be compared to Scenario 8 which differs from Scenario 7 in that real annual price change is 1.0% per year. The other difference between Scenarios 7 and 8 is the silviculture budget level which is again constrained in Scenario 8, albeit at higher levels than in Scenarios 1 to 4. Scenario 8 timber production possibilities in Figure 17 are steeper and peak higher than those in Scenario 7 (Figure 16). A more dramatic difference between Scenarios 7 and 8 is noticeable when comparing Figures 9 and 8. The projections for economically operable AACs with a more optimistic price projection, and a lower but more constant AAC schedule results in more stable and increasing projections of operable AAC in Figure 9.

Finally, a few comments can be made regarding the general characteristics of all simulation Scenarios with the PRTSM and the B.C. Coast data set:

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14 Massie and Brett (1993) provide both history and an up-to-date synopsis of all factors that influence silviculture investment decision-making in British Columbia.

1. There is a measure of consistency across all the eight Scenarios, which suggests that the underlying relationships in the model and its associated assumptions are fairly robust.

2. In Scenarios where costs are much higher than revenues for future periods, this leads to a much slower liquidation of old growth. Where the reverse is true, there is always some proportion of old growth that is beyond the extensive economic margin.

3. The ability or flexibility of the scheduled AACs to respond to price signals can generate significant opportunity costs. Although they were not explicitly calculated in this analysis, the methodology could be used to examine in much greater detail the relationships between harvest schedule policies such as the +/- 10 % over five years variance allowed between harvest level and AAC, and its impact on economic availability (see for example Williams (1993)).

As with any analytical exercise there are a number of caveats and potential weaknesses that must be identified:

1. The level of detail in the PRTSM does not allow for the disaggregation of the data into various log grades, or end-uses of logs. Each analysis unit does however contain the notion of log value by diameter class, but not all possible variation on log value can be captured by this relationship alone.

2. The PRTSM recognizes only one aggregate real average price increase for all logs. Empirical evidence of historical log prices by grade suggests that prices for different grades increase/decrease at significantly different rates.

3. Future price expectations in the PRTSM can only be linear, and other patterns such as random walks, or cyclical variations in real price changes cannot be modeled.

4. Shadow prices cannot be calculated for changes in parameters used in the sensitivity analysis. The PRTSM is strictly a simulation model, and any sensitivity analyses done with simulation techniques is at best partial, subjective, and often biased towards starting and/or ending values. Simulation models, in order to run, need to have pre-defined goals or "seeds" *given* to them. Setting these goals is usually done outside the model, and must therefore rely on another analytical process to generate them, or be based on subjective judgment.

5. The level of aggregation of the B.C. Coast data set confines the utility of the conclusions to "strategic level" analyses. This is not true of the PRTSM, which, with a less aggregated data set could be used for more detailed analyses of much smaller geographic areas of forest.

6. Silviculture Scenarios for a PRTSM data set are confined to four general classes of silvicultural activity, and although there is considerable scope for defining impacts, costs, and success of these activities, there is potential for including even more detail. The limitation is that considerable modifications would have to be made to the PRTSM code to include a higher order of detail.

PART FOUR

Conclusions

The objective of this report is to illustrate with a relatively simple methodology some of the more important economic dimensions of timber supply and harvest levels in Coastal British Columbia. The database that was used, although somewhat dated, serves to show how this type of analysis could be used in an operational sense for strategic level planning.

The B.C. Ministry of Forests is conducting an unprecedented review of timber harvest levels (AAC) across all crown forest land. The result of this analysis will be final determinations of harvest levels for each TSA in the province, to be updated once every five years after December, 1995. It has been predicted that harvest levels could drop by as much as 10-30%, with potentially serious negative economic consequences (Binkely, et al., 1994). This analysis illustrates the importance of the methodology utilized in the PRTSM, and how it can be used to provide answers to:

1. What levels and allocations of silviculture expenditure have the greatest impact in augmenting economically operable wood supplies?

2. What are the opportunity costs associated with various exogenously scheduled harvest levels under different expectations of price?

3. Where are the extensive and intensive margins for different areas of British Columbia, and how are they affected by various supply-side or demand-side factors.?

The relative value of these and other questions that can be answered with the PRTSM will be determined by the extent to which Binkley et al. (1994) are correct about the economic impacts of harvest level reductions in B.C.

In addition to determination of economic production possibilities, the PRTSM can be used to determine broad-level silvicultural budget objectives and outputs., The effects of different expenditure levels and trade-offs can be analyzed along both the extensive and the intensive margins. The results from this analysis suggest that there is likely some optimum level of silviculture expenditures that satisfies timber supply sustainability constraints, and is highly dependent on future price expectations. Allocation of large sums (i.e. unconstrained) silviculture expenditures in the absence of *sufficient* future price expectations, will have little effect on timber availability.

Timber supply has been shown to be highly responsive to price changes both negative and positive, until the biological limits of growing timber are reached, where supply becomes highly price inelastic. Excessively high costs and/or low prices can, with relative ease, render forest growing stock to become no longer "a going concern". This is consistent with previous results from PRTSM analyses in other parts of Canada. Unlike Binkley (1993) the PRTSM timber supply curves were found not to be backward bending at very high price levels. The reason for this is that rotation ages were constrained to be the age of maximum mean annual increment. Had rotation ages been determined as economically optimal rotations, the curves may have eventually bent backwards at high price levels.

Given the number and importance of caveats listed in the previous discussion there is clearly much scope for expanding the detail and richness of this type of analysis. One of the major constraints in achieving this has been technological. Due to the cost and availability of sophisticated software and powerful computer hardware, this constraint no longer exists. The greater challenge at hand is likely the time and expense of collecting and compiling the requisite data sets, which are often not readily available or compatible.

Evaluations of risk or uncertainty with respect to input data are not feasible with the PRTSM. Virtually all types of data used in any timber supply analysis are observed and measured as samples of populations, and thus have associated standard errors and confidence intervals. In order to objectively evaluate the effects of these sources of variation, it is necessary to employ some type of reliability analysis. Sensitivity analysis with a simulation model, as employed is this report, is insufficient to determine the reliability of parameter estimates and their effects on output magnitudes. Use of techniques such as monte carlo analysis, Bayesian analysis, or fuzzy sets would allow outputs from the model to be a function of the possible range in variability in the input. This would allow the decision maker more freedom to include "professional experience and judgment" in estimating parameters where "hard" data are lacking, and objectively rank inputs in terms of their individual contributions to uncertainty in estimating model outputs.

Continuation of this work with Coastal B.C. economic timber supply analysis will include the use of other models that incorporate both simulation, optimization, and treatment of risk and uncertainty. The caveats and weaknesses identified in the previous discussion are areas which can likely be handled with other analytical models, or by upgrading the PRTSM code itself. Other questions regarding the optimal allocation of silviculture expenditures to meet specific wood quality and quantity objectives will also require more novel analytical procedures, and more detailed information about the forest growing stock. New databases can be created and older ones enhanced to incorporate more price and quality disaggregation, and greater detail in silvicultural prescriptions and alternatives.

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APPENDIX I

Graphical Output From the B.C. Coast PRTSM Analysis

Figure 18

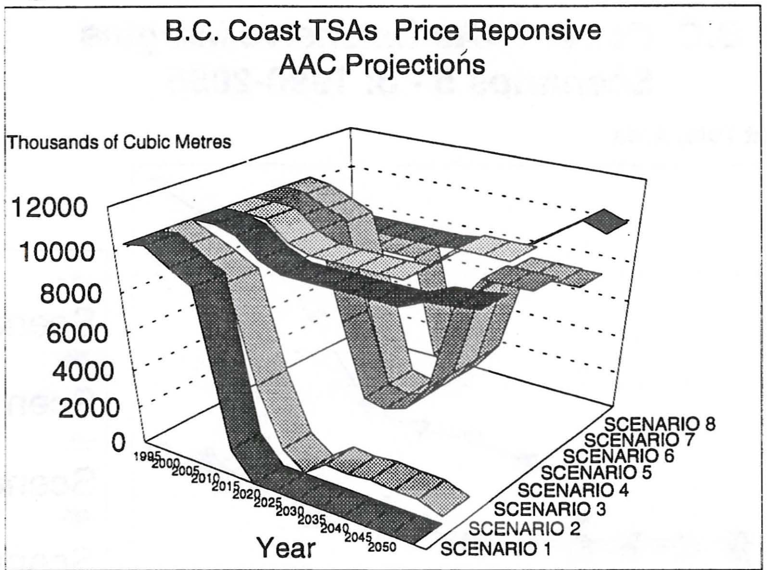


Figure 19

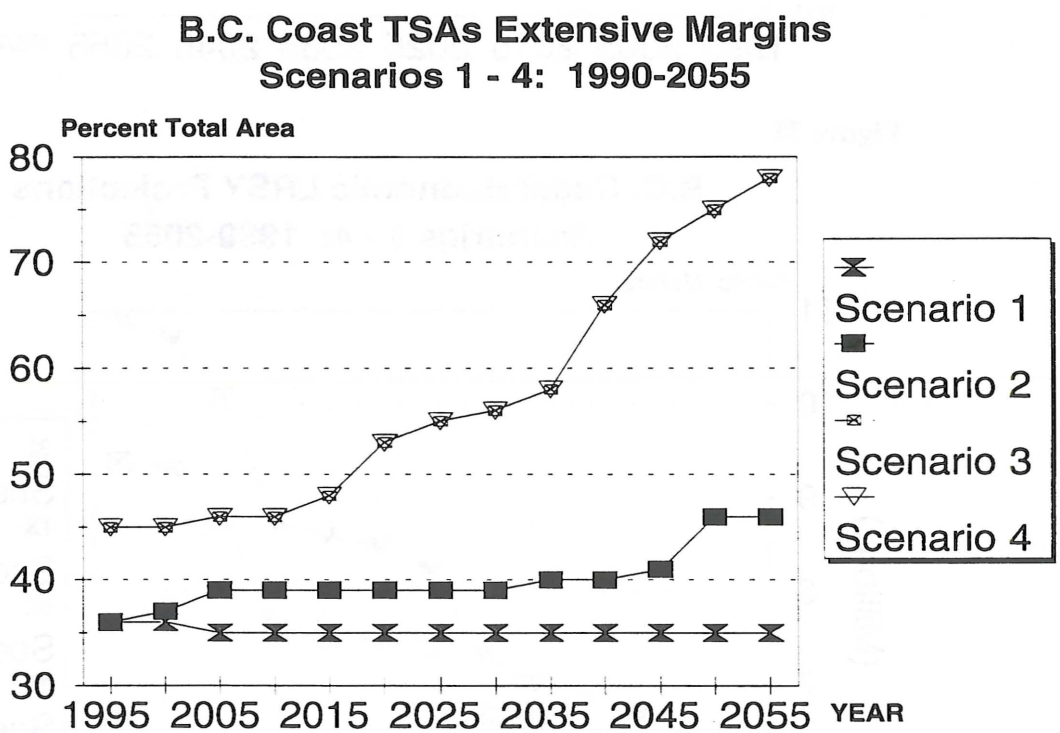


Figure 20

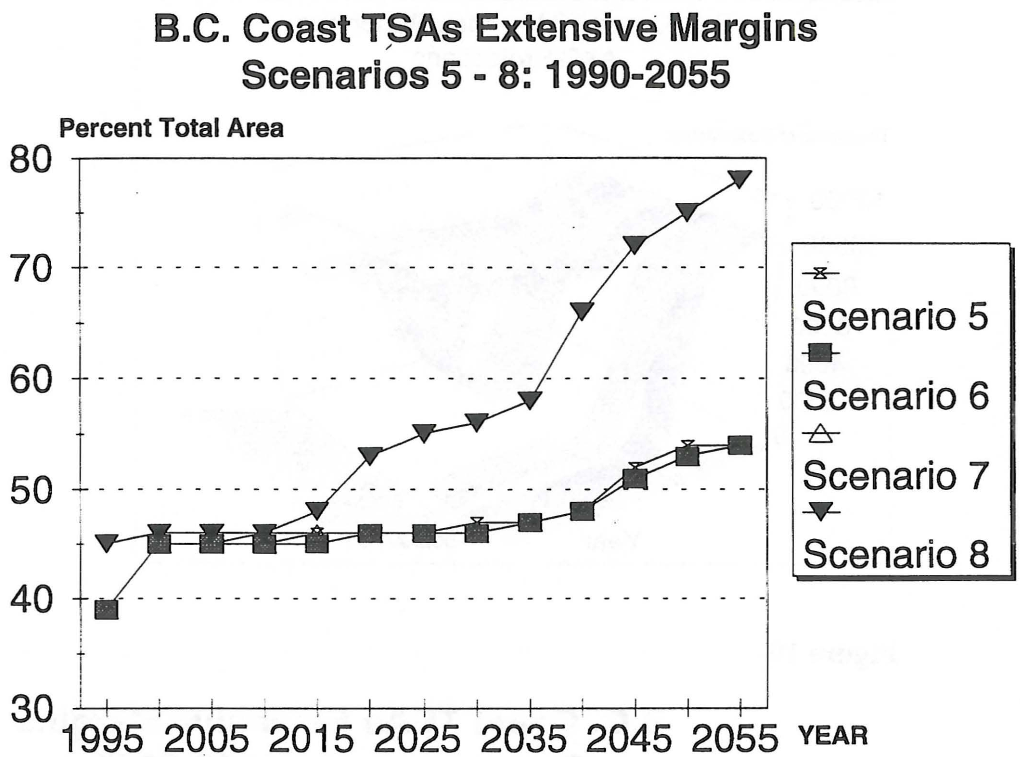


Figure 21

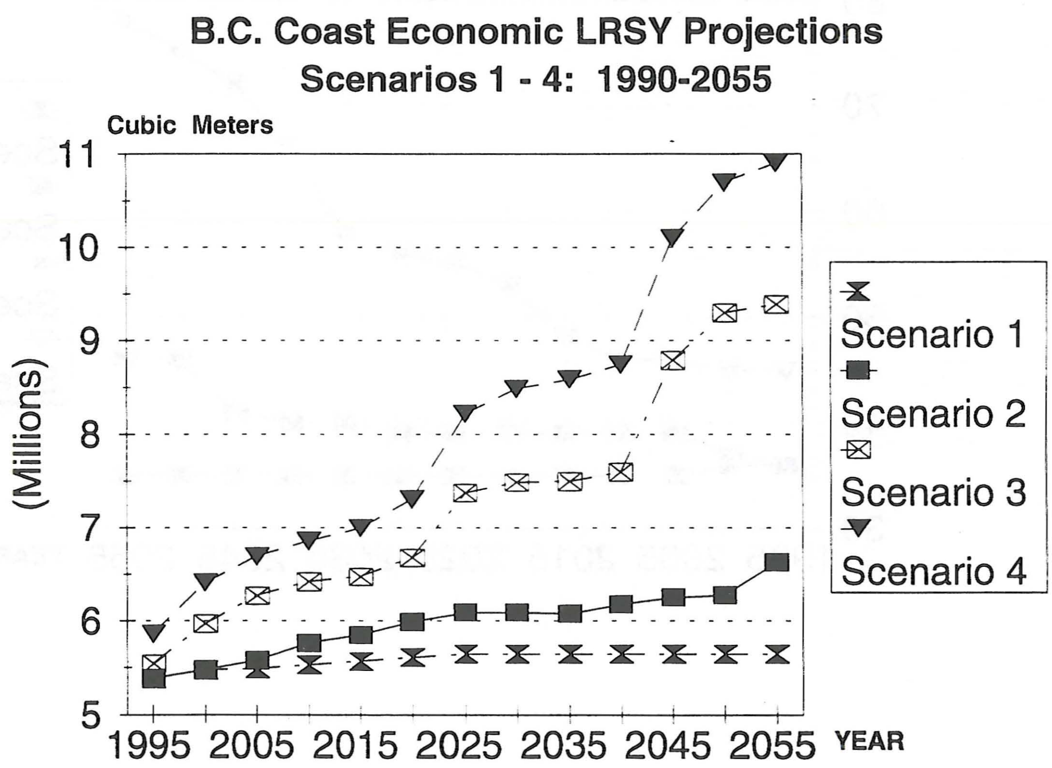


Figure 22

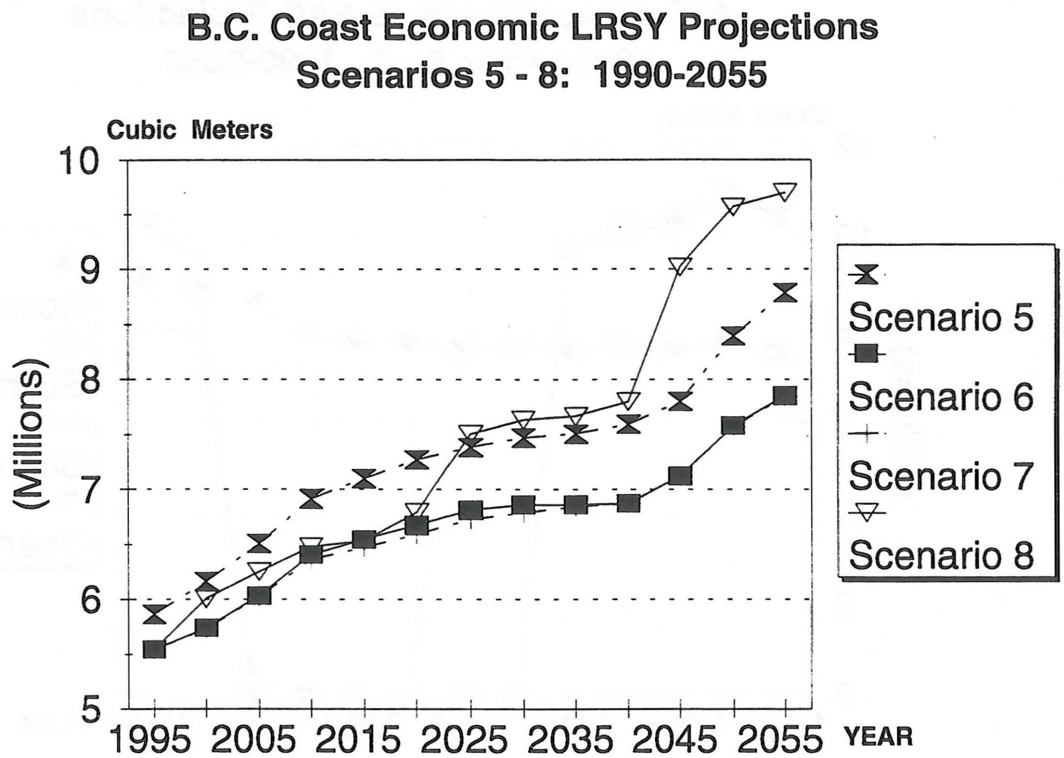


Figure 23

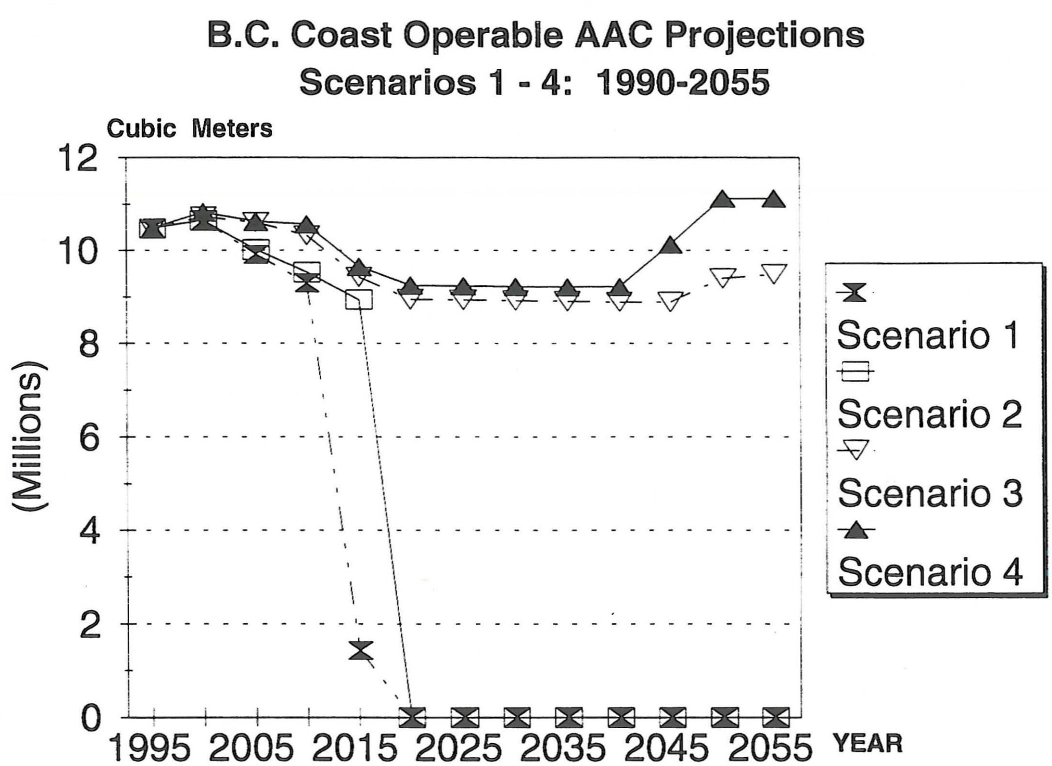
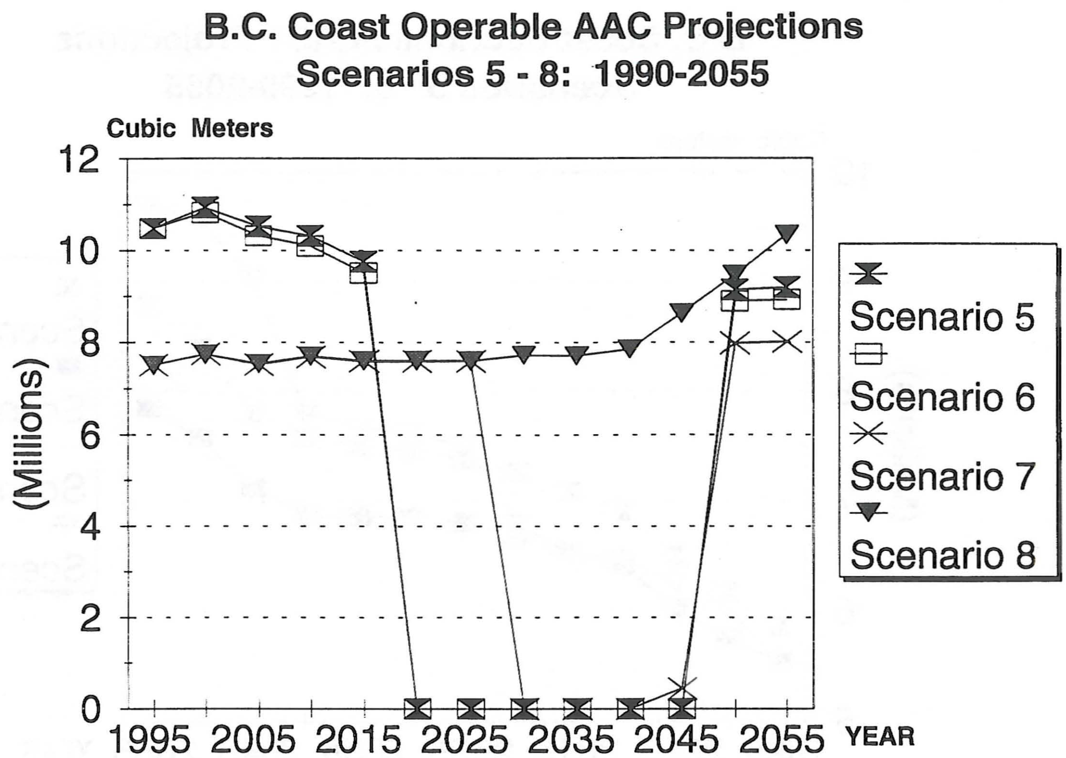


Figure 24


B.C. Coast Operable AAC Projections
Scenarios 5 - 8: 1990-2055
Cubic Meters
(Millions)
12
10
8
6
4
2
0
1995
2005
2015
2025
2035
2045
2055
YEAR
Scenario 5
Scenario 6
Scenario 7
Scenario 8

APPENDIX II

PRTSM Silviculture and Summary Output

Reports for the Eight Scenarios

Scenario 1 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 1: $20 mm. per year silv. budget, Econ. Rot. Age, 4%d-rate,
Oper. Oldest-First Harv., Econ.LRSY,HIGHER Exog. Harv.Sched., 0% real price rate

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.00	10469	10469	36	38	111	100	4327	0	10469	0	848	15.33
2000	1.00	9798	9890	36	-40	110	102	4708	0	9890	0	848	15.33
2005	1.00	9127	9232	35	41	110	102	4992	0	9232	0	848	15.33
2010	1.00	8456	8600	35	43	110	103	5286	0	8600	0	848	15.33
2015	1.00	7785	7968	35	44	110	103	5561	0	286	0	848	15.33
2020	1.00	7785	7968	35	44	110	104	5610	0	7968	0	0	.00
2025	1.00	7785	7968	35	44	110	105	5649	0	7968	0	0	.00
2030	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00
2035	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00
2040	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00
2045	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00
2050	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00
2055	1.00	7785	7968	35	44	110	105	5650	0	7968	0	0	.00

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5385749 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 1 Silviculture Activity Summary

Period Ending	Nat Regen ha	Planting ha	Planting $	Planting PYs	Backlog Rehab ha	Backlog Rehab $	Backlog Rehab PYs	Incremental ha	Incremental $	Incremental PYs	Current NSR (ha) 5	Current NSR (ha) 10	Current NSR (ha) 15	Current NSR (ha) 20	Backlog NSR (ha)
1995	6981	61749	32.33	231291	28071	40.00	119017	0	.00	0	24269	25541	8253	0	10364
2000	24269	58334	30.55	218503	8077	11.87	30883	0	.00	0	41877	24972	384	0	2362
2005	41877	54452	28.51	203962	76	.12	304	13340	10.00	50644	40220	15634	2	0	2287
2010	40220	50727	26.56	190014	0	.00	1	13294	10.00	50555	29839	14203	0	0	2287
2015	29839	1681	.88	6307	0	.00	0	13036	10.00	50041	14675	468	0	0	2287
2020	14675	0	.00	0	0	.00	0	12964	10.00	49900	468	0	0	0	2287
2025	468	0	.00	0	0	.00	0	737	.60	2823	0	0	0	0	2287
2030	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287
2035	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287
2040	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287
2045	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287
2050	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287
2055	0	0	.00	0	0	.00	0	0	.00	0	0	0	0	0	2287

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 2 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 2: $20 mm Silv. Budget, Econ. Rot. Age, 4% d-rate
Oper. Oldest-First Harv., Econ.LRSY,HIGHER Exog. Harv. Sched., 0.3% real price

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.02	10469	10469	36	38	109	100	4304	0	10469	0	844	16.10
2000	1.03	9798	9960	37	40	109	103	4730	0	9960	0	841	16.99
2005	1.05	9127	9461	39	41	111	106	5180	0	9461	0	840	17.58
2010	1.06	8456	8885	39	43	108	108	5497	0	8885	0	826	16.96
2015	1.08	7785	8328	39	44	106	110	5818	0	4003	0	791	12.62
2020	1.09	7785	8328	39	45	104	112	5996	0	949	0	690	.00
2025	1.11	7785	8328	39	45	102	113	6075	0	34	0	894	.00
2030	1.13	7785	8328	39	45	100	113	6055	0	957	0	709	.00
2035	1.14	7785	8328	40	45	99	115	6148	0	869	0	670	.00
2040	1.16	7785	8328	40	45	97	116	6209	0	991	0	704	.00
2045	1.18	7785	8328	41	46	96	116	6238	0	884	0	668	.00
2050	1.20	7785	8328	46	46	104	123	6593	0	849	0	664	.00
2055	1.21	7785	8328	46	46	100	126	6758	0	384	0	671	.00

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5385749 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 2 Silviculture Activity Summary

Period Ending	Nat Regen ha	Planting ha	Planting $	Planting PYs	Backlog Rehab ha	Backlog Rehab $	Backlog Rehab PYs	Incremental ha	Incremental $	Incremental PYs	Current NSR (ha) 5	Current NSR (ha) 10	Current NSR (ha) 15	Current NSR (ha) 20	Backlog NSR (ha)
1995	6980	61995	32.08	229688	28071	40.00	119017	0	.00	0	24337	25610	8253	0	10364
2000	24337	59201	30.30	217079	8077	11.87	30883	0	.00	0	42189	25214	383	0	2362
2005	42189	56280	28.78	205930	76	.12	304	13340	10.00	50645	40973	16145	2	0	2287
2010	40973	53800	26.19	187786	0	.00	1	13279	10.00	50526	31213	15064	0	0	2287
2015	31213	25301	10.77	77658	0	.00	0	13036	10.00	50044	22148	7081	0	0	2287
2020	22148	6873	2.04	14542	0	.00	0	12908	10.00	49797	9005	1919	0	0	2287
2025	9005	190	.07	532	0	.00	0	11130	9.06	42950	1972	52	0	0	2287
2030	1974	6753	2.02	14497	0	.00	0	3020	2.53	11849	1940	1888	0	0	2287
2035	1941	6484	1.92	13330	0	.00	0	83	.07	325	3704	1815	0	0	2287
2040	3704	7038	2.06	15190	0	.00	0	2969	2.48	11528	3785	1968	0	0	2287
2045	3783	6616	1.97	13475	0	.00	0	2851	2.39	11213	3821	1851	0	0	2287
2050	3821	6397	1.91	12961	0	.00	0	3095	2.58	12133	3642	1789	0	0	2287
2055	3642	2858	.88	5500	0	.00	0	2908	2.44	11384	2589	798	0	0	2287

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 3 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 3: $20 mm Silv. Budget, Ec.Rot., 4% d-rate 20% 1st per.price shock
Oper. Oldest-First Harvest, Econ.LRSY, HIGHER Exog. Harvest Schedule, 1.0% real

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Harvest Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.05	10469	10469	45	38	114	105	4726	0	10469	0	838	17.96
2000	1.10	9798	10469	45	40	98	112	5308	0	10469	0	827	20.66
2005	1.16	9127	10175	46	41	93	114	5652	0	10175	0	810	22.08
2010	1.22	8456	9302	46	43	90	115	5928	0	9302	0	789	23.13
2015	1.28	7785	8842	48	45	86	119	6178	0	8842	0	819	12.72
2020	1.35	7785	8842	53	46	84	132	6364	0	8842	0	866	4.92
2025	1.42	7785	8842	55	47	82	134	6502	0	8842	0	853	6.74
2030	1.49	7785	8842	56	49	81	134	6664	0	8842	0	786	9.95
2035	1.56	7785	8842	58	50	81	136	6838	0	8842	0	674	11.74
2040	1.64	7785	8842	66	52	80	158	6988	0	8842	0	695	6.78
2045	1.73	7785	9375	72	54	81	167	7219	0	9375	0	626	8.21
2050	1.82	7785	9471	75	56	81	169	7374	0	9471	0	570	10.72
2055	1.91	7785	9616	78	58	81	172	7588	0	9616	0	539	13.11

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5543461 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 3 Silviculture Activity Summary

Period Ending	Nat Regen ha	Planting ha	Planting $	Planting PYs	Backlog Rehab ha	Backlog Rehab $	Backlog Rehab PYs	Incremental ha	Incremental $	Incremental PYs	Current NSR (ha) 5	Current NSR (ha) 10	Current NSR (ha) 15	Current NSR (ha) 20	Backlog NSR (ha)
1995	6979	62484	31.63	226681	28071	40.00	119017	0	.00	0	24474	25747	8252	0	10364
2000	24474	63260	31.01	222212	8077	11.87	30883	0	.00	0	43462	26349	384	0	2363
2005	43462	62771	29.20	209274	76	.12	304	13340	10.00	50645	43928	17961	2	0	2287
2010	43928	58927	26.00	184699	0	.00	1	13260	10.00	50488	34464	16499	0	0	2287
2015	34489	53932	21.50	156003	0	.00	0	12946	10.00	49867	31602	15098	0	0	2287
2020	31615	51037	19.09	143433	0	.00	0	12755	10.00	49494	29390	14287	0	0	2285
2025	29451	51754	19.26	142321	0	.00	0	12272	10.00	47778	28781	14488	0	0	2285
2030	28849	56159	20.73	148498	0	.00	0	12038	10.00	47698	30211	15720	0	0	2285
2035	30635	65143	23.57	162419	0	.00	0	12025	10.00	47724	33960	18234	0	0	2285
2040	34338	63227	20.50	144199	0	.00	0	12024	10.00	47741	35938	17696	0	0	2283
2045	36401	74380	24.11	168447	0	.00	0	12029	10.00	47908	38526	20820	0	0	2283
2050	39530	82141	27.18	184009	0	.00	0	12004	10.00	47924	43821	22992	0	0	2283
2055	45139	87810	29.58	195097	0	.00	0	12008	10.00	47984	47579	24582	0	0	2283

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 4 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 4: $20 mm Silv. Budget, Ec.Rot., 2.5% d-rate 20% 1st per.price shock
Oper. Oldest-First Harvest, Econ.LRSY,HIGHER Exog. Harvest Schedule, 1.0% real p

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.05	10469	10469	45	38	124	106	5015	0	10469	0	838	17.96
2000	1.10	9798	10469	45	40	109	113	5647	0	10469	0	827	20.66
2005	1.16	9127	10404	46	41	104	115	6023	0	10404	0	810	22.08
2010	1.22	8456	9518	47	43	101	118	6397	0	9518	0	789	23.09
2015	1.28	7785	9132	48	45	98	123	6746	0	9132	0	820	12.34
2020	1.35	7785	9132	54	46	96	139	7052	0	9132	0	867	4.65
2025	1.42	7785	9132	55	48	94	143	7332	0	9132	0	854	6.49
2030	1.49	7785	9132	56	49	94	145	7605	0	9132	0	784	9.68
2035	1.56	7785	9132	58	51	94	148	7847	0	9132	0	669	11.40
2040	1.64	7785	10046	66	52	94	171	8082	0	10046	0	693	6.42
2045	1.73	7785	11050	72	54	94	181	8376	0	11050	0	623	7.85
2050	1.82	7785	11050	76	57	94	185	8689	0	11050	0	564	10.32
2055	1.91	7785	11050	79	59	94	188	8992	0	11050	0	533	12.62

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5862640 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 4 Silviculture Activity Summary

Period Ending	Nat Regen ha	Planting ha	Planting $	Planting PYs	Backlog Rehab ha	Backlog Rehab $	Backlog Rehab PYs	Incremental ha	Incremental $	Incremental PYs	Current NSR (ha) 5	Current NSR (ha) 10	Current NSR (ha) 15	Current NSR (ha) 20	Backlog NSR (ha)
1995	6979	62484	31.63	226681	28071	40.00	119017	0	.00	0	24474	25747	8252	0	10364
2000	24474	63260	31.01	222212	8077	11.87	30883	0	.00	0	43462	26349	384	0	2363
2005	43462	64184	29.86	213988	76	.12	304	13340	10.00	50645	44324	18356	2	0	2287
2010	44324	60315	26.59	188903	0	.00	1	13260	10.00	50488	35249	16887	0	0	2287
2015	35276	55659	22.12	160576	0	.00	0	12968	10.00	49910	32474	15579	0	0	2286
2020	32487	52655	19.66	147823	0	.00	0	12771	10.00	49525	30325	14738	0	0	2286
2025	30389	53422	19.85	146708	0	.00	0	12269	10.00	47753	29699	14953	0	0	2286
2030	29770	58136	21.42	153333	0	.00	0	12032	10.00	47705	31231	16272	0	0	2286
2035	31687	67817	24.49	168379	0	.00	0	12024	10.00	47730	35262	18981	0	0	2285
2040	35698	71989	23.26	163520	0	.00	0	12019	10.00	47746	39139	20151	0	0	2283
2045	39693	88120	28.50	198983	0	.00	0	12026	10.00	47906	44824	24666	0	0	2283
2050	46039	96709	31.98	216021	0	.00	0	12005	10.00	47921	51748	27072	0	0	2283
2055	53327	102092	34.41	226140	0	.00	0	12007	10.00	47976	55659	28577	0	0	2283

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 5 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 5:Unlimited silv. Budget, Ec.Rot., 2.5% d-rate 20% 1st per.price shock
Oper. Oldest-First Harvest, Econ.LRSY, HIGHER Exog. Harvest Schedule, 0.5% real

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.03	10469	10469	39	38	110	101	4770	0	10469	0	844	16.69
2000	1.05	9798	10436	45	40	123	110	5571	0	10436	0	835	17.67
2005	1.08	9127	9920	45	41	112	114	6028	0	9920	0	828	18.34
2010	1.10	8456	9551	46	43	109	119	6585	0	9551	0	816	19.05
2015	1.13	7785	9073	46	45	105	122	7003	0	5061	0	774	14.13
2020	1.16	7785	9073	46	45	103	124	7250	0	1141	0	686	.06
2025	1.19	7785	9073	46	46	102	126	7382	0	892	0	670	.00
2030	1.22	7785	9073	47	46	101	128	7447	0	1321	0	666	.56
2035	1.25	7785	9073	47	46	99	129	7502	0	2834	0	821	.03
2040	1.28	7785	9073	48	47	98	132	7575	0	7589	0	813	.09
2045	1.32	7785	9073	52	48	97	142	7789	0	9073	0	896	.55
2050	1.35	7785	9073	54	49	96	148	8051	0	9073	0	888	1.58
2055	1.38	7785	9073	54	50	94	152	8357	0	9073	0	874	2.03

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5862640 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 5 Silviculture Activity Summary

Period	Nat Regen	-- Planting ---			- Backlog Rehab -			-- Incremental --			-- Current NSR (ha) --				Backlog
Ending	ha	ha	$	PYs	ha	$	PYs	ha	$	PYs	5	10	15	20	NSR (ha)
1995	6979	61998	32.09	229733	35869	51.47	148712	0	.00	0	24339	25985	8626	0	2641
2000	24339	62451	31.38	224945	354	.51	1482	0	.00	0	43473	26128	13	0	2288
2005	43473	59926	29.32	210196	1	.01	12	59429	47.57	225366	42909	16790	0	0	2287
2010	42909	58526	27.64	198130	0	.00	0	27795	22.41	106330	33181	16384	0	0	2287
2015	33181	32695	13.29	95967	0	.00	0	26366	21.30	100963	25540	9151	0	0	2286
2020	25540	8318	2.51	17270	0	.00	0	25748	20.86	98802	11479	2325	0	0	2286
2025	11479	6660	1.98	13594	0	.00	0	14384	11.78	55704	4189	1858	0	0	2286
2030	4191	9928	3.04	19347	0	.00	0	3658	3.06	14187	4636	2778	0	0	2286
2035	4675	17218	6.12	44737	0	.00	0	2928	2.46	11462	7597	4819	0	0	2286
2040	7614	46643	16.73	120202	0	.00	0	4365	3.68	16928	17878	13057	0	0	2285
2045	17894	50613	18.63	143722	0	.00	0	7573	6.32	30148	27230	14170	0	0	2285
2050	27238	51087	18.80	143653	0	.00	0	20519	17.13	81659	28475	14302	0	0	2286
2055	28481	51911	19.06	143346	0	.00	0	22268	18.55	89048	28838	14534	0	0	2286

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 6 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT
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Scenario 6:Unlimited silv. Budget, Ec.Rot., 4.0% d-rate 20% 1st per.price shock
Oper. Oldest-First Harvest, Econ.LRSY,HIGHER Exog. Harvest Schedule, 0.5% real p

Period	Price	----- AAC ---		X-Margin	%		%	Incre-	Depl-	---------- Harvest ----------			
		Sched	Adjust	Total	GS	Rota-	LRSY	ment	etion	Qs	GS	Yield	Return
Ending	Index	-- m3 x1000 --		Area	Area	tion	------- m3 x1000 ---------				%	m3/ha	$/m3
1995	1.03	10469	10469	39	38	99	100	4505	0	10469	0	844	16.69
2000	1.05	9798	10275	45	40	113	108	5189	0	10275	0	835	17.67
2005	1.08	9127	9815	45	41	101	112	5646	0	9815	0	828	18.35
2010	1.10	8456	9359	45	43	97	116	6094	0	9359	0	816	19.09
2015	1.13	7785	8829	45	44	95	119	6438	0	5519	0	777	14.72
2020	1.16	7785	8829	46	45	93	121	6702	0	1141	0	686	.06
2025	1.19	7785	8829	46	46	91	123	6777	0	892	0	670	.00
2030	1.22	7785	8829	46	46	90	123	6806	0	1321	0	666	.56
2035	1.25	7785	8829	47	46	88	124	6795	0	2834	0	821	.03
2040	1.28	7785	8829	48	47	86	128	6929	0	7589	0	813	.09
2045	1.32	7785	8829	51	48	85	136	7057	0	8829	0	896	.55
2050	1.35	7785	8829	53	49	84	140	7232	0	8829	0	888	1.59
2055	1.38	7785	8829	54	50	83	143	7447	0	8829	0	874	2.05

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5543461 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 6 Silviculture Activity Summary

Period	Nat Regen	-- Planting ---			- Backlog Rehab -			-- Incremental --			-- Current NSR (ha) --				Backlog
Ending	ha	ha	$	PYs	ha	$	PYs	ha	$	PYs	5	10	15	20	NSR (ha)
1995	6979	61998	32.09	229733	35869	51.47	148712	0	.00	0	24339	25985	8626	0	2641
2000	24339	61488	30.90	221472	354	.51	1482	0	.00	0	43203	25857	13	0	2288
2005	43203	59286	29.02	207994	1	.01	12	59429	47.57	225366	42461	16612	0	0	2287
2010	42461	57330	27.10	194262	0	.00	0	27375	22.07	104705	32666	16050	0	0	2287
2015	32666	35495	14.62	105509	0	.00	0	26087	21.07	99889	25988	9934	0	0	2287
2020	25988	8318	2.51	17270	0	.00	0	25223	20.44	96783	12262	2325	0	0	2287
2025	12262	6660	1.98	13594	0	.00	0	15613	12.78	60424	4189	1861	0	0	2287
2030	4191	9928	3.04	19347	0	.00	0	3658	3.06	14187	4639	2777	0	0	2287
2035	4675	17218	6.12	44737	0	.00	0	2928	2.46	11462	7596	4819	0	0	2287
2040	7614	46643	16.73	120202	0	.00	0	4365	3.68	16928	17878	13057	0	0	2286
2045	17893	49256	18.13	139869	0	.00	0	7573	6.32	30148	26849	13789	0	0	2287
2050	26857	49712	18.29	139800	0	.00	0	20519	17.13	81659	27709	13918	0	0	2286
2055	27715	50497	18.55	139508	0	.00	0	21671	18.06	86660	28057	14138	0	0	2286

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 7 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 7:Unlimited silv. Budget, Ec.Rot., 4.0% d-rate 20% 1st per.price shock
Oper. Oldest-First Harv., Econ.LRSY, LOWER Exog. Harvest Schedule, 0.5% real pri

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.03	7500	7500	39	38	99	100	4505	0	7500	0	844	16.69
2000	1.05	7500	7500	45	39	113	108	5106	0	7500	0	836	17.77
2005	1.08	7500	7500	45	40	101	112	5473	0	7500	0	830	18.68
2010	1.10	7500	7500	45	42	97	115	5834	0	7500	0	823	20.01
2015	1.13	7500	7500	46	43	95	118	6104	0	7500	0	807	19.55
2020	1.16	7500	7500	46	44	93	120	6400	0	7500	0	790	18.85
2025	1.19	7500	7500	46	45	91	121	6650	0	2469	0	742	13.13
2030	1.22	7500	7500	46	46	90	122	6738	0	1321	0	666	.56
2035	1.25	7500	7500	47	46	88	123	6782	0	2834	0	821	.03
2040	1.28	7500	7500	48	47	86	128	6929	0	7500	0	813	.09
2045	1.32	7500	7936	51	48	85	136	7055	0	7936	0	896	.56
2050	1.35	7500	7936	53	49	84	140	7209	0	7936	0	888	1.63
2055	1.38	7500	7936	54	50	83	142	7403	0	7936	0	875	2.12

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5543461 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 7 Silviculture Activity Summary

Period Ending	Nat Regen ha	Planting ha	Planting $	Planting PYs	Backlog Rehab ha	Backlog Rehab $	Backlog Rehab PYs	Incremental ha	Incremental $	Incremental PYs	Current NSR (ha) 5	Current NSR (ha) 10	Current NSR (ha) 15	Current NSR (ha) 20	Backlog NSR (ha)
1995	6977	44416	22.99	164585	35869	51.47	148712	0	.00	0	19414	21060	8626	0	2641
2000	19414	44840	22.59	161916	354	.51	1482	0	.00	0	33620	21198	13	0	2288
2005	33620	45176	22.29	159749	1	.01	12	51692	41.34	195834	33850	12661	0	0	2287
2010	33850	45581	22.00	157683	0	.00	0	20047	16.16	76674	25427	12757	0	0	2287
2015	25427	46438	21.31	153069	0	.00	0	19878	16.05	76092	25763	12999	0	0	2286
2020	25763	47475	20.70	148103	0	.00	0	20051	16.22	76858	26293	13287	0	0	2286
2025	26293	16636	6.34	44726	0	.00	0	20428	16.59	78565	17947	4653	0	0	2286
2030	17947	9928	3.04	19347	0	.00	0	20885	17.04	80416	7432	2775	0	0	2286
2035	7466	17218	6.12	44737	0	.00	0	7319	6.04	28363	7595	4818	0	0	2286
2040	7614	46096	16.54	118797	0	.00	0	4365	3.68	16928	17725	12904	0	0	2285
2045	17740	44288	16.30	125712	0	.00	0	7573	6.32	30148	25305	12398	0	0	2285
2050	25313	44677	16.44	125655	0	.00	0	20280	16.93	80706	24908	12507	0	0	2286
2055	24915	45328	16.65	125411	0	.00	0	19485	16.24	77919	25200	12690	0	0	2285

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.

Scenario 8 Summary Report and Silviculture Report

TIMBER SUPPLY PROJECTION SUMMARY REPORT

Scenario 8:$30mm silv. Budget, Ec.Rot., 4.0% d-rate 20% 1st per.price shock
Oper. Oldest-First Harv., Econ.LRSY, LOWER Exog. Harvest Schedule, 1.0% real pri

Period Ending	Price Index	AAC Sched (m3 x1000)	AAC Adjust (m3 x1000)	X-Margin Total Area	% GS Area	Rotation	% LRSY	Increment (m3 x1000)	Depletion (m3 x1000)	Qs (m3 x1000)	Harvest GS %	Harvest Yield m3/ha	Harvest Return $/m3
1995	1.05	7500	7500	45	38	114	105	4726	0	7500	0	838	17.96
2000	1.10	7500	7500	46	39	98	112	5261	0	7500	0	828	20.78
2005	1.16	7500	7500	46	41	93	114	5475	0	7500	0	814	22.69
2010	1.22	7500	7500	46	42	90	116	5762	0	7500	0	799	24.75
2015	1.28	7500	7500	48	43	86	121	6006	0	7500	0	815	19.12
2020	1.35	7500	7500	53	44	84	134	6186	0	7500	0	854	9.80
2025	1.42	7500	7637	55	45	82	136	6324	0	7637	0	846	11.40
2030	1.49	7500	7637	56	47	81	137	6489	0	7637	0	797	14.69
2035	1.56	7500	7780	58	48	81	139	6673	0	7780	0	712	16.78
2040	1.64	7500	8558	66	49	81	161	6839	0	8558	0	710	11.05
2045	1.73	7500	9414	72	51	81	171	7085	0	9414	0	647	12.04
2050	1.82	7500	10281	75	53	81	174	7287	0	10281	0	594	14.52
2055	1.91	7500	9875	78	55	81	177	7550	0	9875	0	564	16.98

Note (1) The extensive margin of the inventory area is based on the area of the growing stock and old growth.
(2) Initial LRSY is 5543461 cubic metres per year.
(3) Initial price index (margin adjustment) is: 1.000
(4) Volume yield adjustment is: .000

Scenario 8 Silviculture Activity Summary

Period	Nat Regen	-- Planting ---			- Backlog Rehab -			-- Incremental --			-- Current NSR (ha) --				Backlog
Ending	ha	ha	$	PYs	ha	$	PYs	ha	$	PYs	5	10	15	20	NSR (ha)
1995	6978	44765	22.66	162400	34699	50.00	145642	0	.00	0	19512	21107	8574	0	3800
2000	19512	45273	22.25	159460	1513	1.97	4522	0	.00	0	33785	21316	64	0	2298
2005	33785	46047	21.69	155425	11	.02	41	50127	40.00	190322	34214	12958	0	0	2287
2010	34214	46901	21.30	151737	0	.00	0	21219	17.17	81403	26090	13127	0	0	2287
2015	26103	45989	19.45	140208	0	.00	0	20272	16.44	77793	26005	12873	0	0	2287
2020	26015	43885	17.06	126760	0	.00	0	20634	16.79	79298	25160	12281	0	0	2285
2025	25203	45075	17.35	127541	0	.00	0	20232	16.61	78656	24905	12615	0	0	2287
2030	24952	47847	18.25	131227	0	.00	0	19304	16.00	76361	26015	13392	0	0	2286
2035	26284	54357	20.30	141933	0	.00	0	19831	16.45	78560	28615	15216	0	0	2285
2040	28932	59925	20.16	142320	0	.00	0	20997	17.42	83272	31996	16773	0	0	2283
2045	32409	72378	24.09	168944	0	.00	0	23754	19.73	94380	37042	20258	0	0	2284
2050	37987	85646	28.89	197097	0	.00	0	26043	21.67	103839	44242	23974	0	0	2284
2055	45419	86381	29.52	196690	0	.00	0	31341	26.08	125069	48161	24179	0	0	2284

Notes: 1) All costs are in millions of dollars.
2) Area of natural regeneration includes regeneration from 5-year NSR.