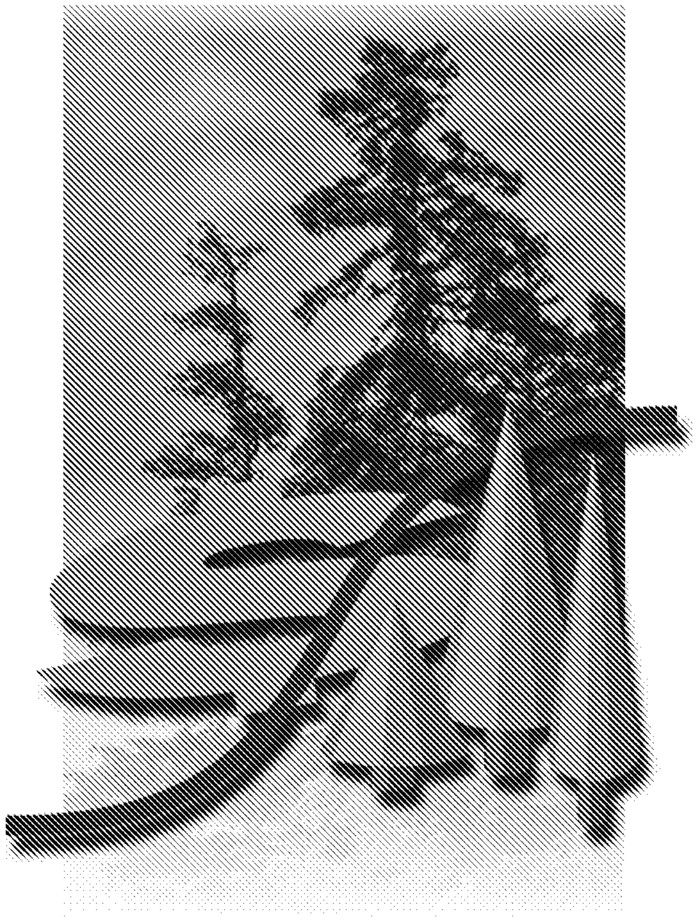

Evaluating Silviculture Projects

Readings and Excerpts

Economic princples of timber production

Forest estate models

Predicting future timber values

FOREST SERVICE · BRITISH COLUMBIA

FOREST RENEWAL BC

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Economic principles of timber production
Source: Stand Density Management Guidebook (Draft), BCFS, 1997

Introduction

These principles provide a production economics background for evaluating stand density management options. Production economics is the process of determining which, among all treatment options capable of meeting forest management objectives, will maximize the return on treatment investment for the forest estate owner. This approach is consistent with the philosophy that the purpose of stand density management is to achieve the timber and non-timber production objectives of a forest management plan.

These stand level economics principles are not intended to address social welfare objectives such as income distribution or employment creation (see *Social objectives* on page 39, in Forest planning considerations). In the following section, Forest planning considerations, economic issues are addressed at the forest level.

Density management activities as investments

Stands in British Columbia exhibit great variability in growing conditions and capacity for timber production. This results in a wide range of economic conditions for making silvicultural investment decisions. Assessing the economics of a proposed silvicultural activity requires information about benefits and costs of the activity from the time of stand establishment to the time of expected harvest. Costs and benefits may be actual, if they have occurred, or expected if they are anticipated in the future. Expected costs or benefits are estimates, and may differ from actual costs and benefits when they occur. Estimation therefore involves accounting for the uncertainty surrounding their actual values.

Information about the timing of stand activities is also required, since various costs and benefits usually occur during different time periods over the life of a stand. Economic analysis converts all costs and benefits to value in today's dollars. This conversion process is referred to as discounting (see *Selecting a discount rate* on page 35). The net present value (NPV) is the sum of all discounted benefits of silvicultural activity or regime, less discounted costs.

Regeneration costs such as site preparation and planting are incurred within the first few years, whereas density management costs are incurred between stand age 10 and 30. Final stand net revenues (revenue less harvest cost) are obtained at the end of the expected rotation period. The procedure for calculating the net present value of a density management treatment in a single stand is straightforward; the net present value of a juvenile spaced stand is compared to that of the same stand without spacing.

In order to make economic comparisons between different stands or different treatments, however, net present value must be calculated over the same time period. That is, for each present value, the starting point must be the same for each stand or treatment, and the end point must be the same expected rotation length. Since the timing of different stand treatments and the rotation lengths of different stands are rarely the same, it is often impossible to compare treatments and stands in this manner. In these circumstances, the net present values must be converted to a site value (SV).

A site value is the present value of an infinite number of successive rotations on a site managed under the same regime. An economic comparison of two or more stand management regimes is made possible by calculating and comparing the site value of each, even though they may differ in the timing of stand treatments or expected final harvest.

Economic analysis provides a means of ranking the economic attractiveness of treatment options, thereby allowing appropriate allocation of silviculture expenditures. Ranking criteria may reflect either profit maximization or cost minimization objectives. Either single treatment or multiple treatment regime options may be analysed in this manner. A preferred treatment or regime selected in this manner may be applied to other similar stands (stand type/site quality) within the same management unit without the need for further, separate analyses.

From this brief overview of stand-level investment procedures, one can see that both the timing and relative value of treatment costs and benefits are important factors in the calculation of net present value and site value.

Revenue assumptions

Future forest product market conditions must be predicted in order to compare the economic efficiency of various silvicultural investments. Because the timber production benefits of silvicultural investments are usually not obtained for 40 to 80 years, estimating future forest product prices is fraught with uncertainty. The assumptions used to make them are key considerations in an economic analysis. Three factors influence revenue forecasts; valuation point, real price changes and the relationship between piece size (tree or log) and price.

Valuation point

For simplicity, the value of harvested timber can be derived from the selling price of manufactured end-products. A common practice is to evaluate the timber as it moves up manufacturing stages to a point where a market price for a product can be determined. At that point any wood quality differences that affect the product are reflected in the price.

In the coastal region of British Columbia the end-product values are derived from log transactions on the Vancouver Log Market (Ministry of Forests, 1995b). In the interior, where log markets are uncommon, a market value is derived from processed lumber and residual wood chips (Ministry of Forests, 1995a).

Real price changes

Since the effect of a silvicultural treatment on stand revenue will not be realised for a considerable time, the potential for change in the real value of wood products, either upwards or downwards, should be considered (see Appendix 1). An important principle applies; time itself has no effect on prices. Rather, market supply and demand forces, which change over time, are the cause of price changes.

Simple price-trend models are sometimes used inappropriately to predict future prices. They assume the forces of supply and demand which caused past price changes are closely correlated with time, and will continue in the future. This assumption may not be valid, and caution is advised in using historical price trends to predict future product values.

Piece size and price

Currently a large log commands a higher price than a small log, all other wood quality characteristics held constant. This price premium is due to the larger dimension and usually more highly valued products which can be manufactured from large logs, as well as the higher product recovery rates associated with a larger piece size. However, many other characteristics influence the price of a log. Stand density management treatments affect a number of log quality characteristics, such as log taper, knot size and distribution, number of growth rings per inch, and the proportion of lower strength juvenile wood. These stand density-related characteristics may have important impacts on future stand values (Jozsa and Middleton 1994; Middleton *et al* 1995; Kellogg, R.M. 1989).

Whether the price premiums associated with larger piece sizes will be maintained in the future depends on how future markets will value piece size and stand density-related wood quality characteristics. Changes in harvesting systems, manufacturing processes and wood products design will likely encourage better utilization of small dimension logs, higher recovery rates during manufacturing, and greater use of engineered wood products as substitutes for large dimension timber components. These factors suggest a gradual decline in the price premium for large logs.

The revenue assumptions used in an economic analysis must be clearly defined, and the analyst should provide evidence supporting all assumptions. Assumptions must also be consistently applied in comparisons of different density management options. For example, an assumption of increasing real prices for large logs made in an analysis of a juvenile spacing option must also be made for an analysis of a commercial thinning option. Different prices in a comparitive analysis would allow no basis for comparison.

Harvesting costs

Harvesting costs can be categorized by harvesting phase, such as road and site development costs, tree-to-truck (felling and yarding) costs, log haul (loading, truck haul, towing, or barging) costs, and administration and overhead costs. The effects of density management on each cost phase must be accounted for in any analysis.

Development, overhead and administrative costs are examples of fixed harvesting costs. Density management treatments which result in changes to the volume of timber produced by a stand will not affect total fixed harvesting costs, but will affect the average fixed costs per cubic meter of timber produced.

Density management treatments have a larger impact on certain components of tree-to-truck and log haul costs, which are examples of variable costs. For instance, log haul costs are influenced primarily by changes in loading time resulting from the number of logs required to complete a load. However, the cost of the loading component of log haul costs is relatively small. Density management practises have greatest impact on tree-to-truck costs, particularly the yarding component.

Although cable yarding systems are affected by piece size differences more than ground based skidding operations, it is turn size, not piece size that directly determines yarding costs. Piece size influences turn size, however yarding operators are often able to adjust their equipment configuration to reduce the effects of piece size variation.

For further information on more detailed aspects of harvesting costs, refer to the Ministry of Forests Appraisal Manuals (Ministry of Forests, 1995(a),(b) as well as Stone (1996 a) and Stone, *et al*. (1996).

Milling costs

Milling costs need not be accounted for in economic analysis based on log values, since the log prices used in the analysis should already reflect differences in milling costs. However, when the analysis is based on lumber and wood chip end products, the effects of density management treatments on milling costs must be accounted for. Larger log sizes result in lower milling costs, although other factors, such as log taper, must also be considered. Stone (1996 a), and Stone *et al.* (1996) illustrate a method for predicting changes in milling costs.

Silviculture Treatment Costs

The cost of stand density treatments is usually a function of site and stand conditions such as road access and travel distance, the average slope of the site, original stand density and the number of trees removed, and the average height and diameter of the trees removed. Local labour market conditions may also influence treatment prices. For instance, the number of silviculture operators available to bid on a project and the amount of work currently under contract may have a substantial effect on treatment prices. Local market treatment costs should be used to assess density management options. If this information is unavailable regional average costs may be used.

Selecting of a discount rate

Silvicultural investments are characterised by treatment costs and benefits which occur in different time periods through the rotation. These costs and benefits must be converted to present values in order to assess investment efficiency. The purpose of a discount rate in an economic analysis is to reflect the preference that societies, organisations, or individuals have for present, versus future consumption.

Income received, or costs incurred today are considered to be worth more than income or costs which occur in some future time period. The rate of discount is used to determine how much less future revenues or expenditures represent in today's dollars. Discounting permits a comparison of various flows of benefits and costs occurring over time in a consistent and logical manner.

Choice of a discount rate is influenced by markets for capital, opportunity costs of capital, risk, and perceptions of risk, uncertainty, inflation expectations, differences in the rate of borrowing and lending, as well as other factors. Governments and private sectors are both influenced by these factors, however private sectors of the economy are affected to a greater degree due to uncertainties in future product demand, natural resource conservation policies, and the wider range of alternative investment opportunities available.

Heaps and Pratt (1989), in “The Social Discount Rate for Silvicultural Investments”, estimated the discount rate using the social opportunity cost of capital for public sector investments in Canada, and found a range of between 3 and 7%, depending on how risk and uncertainty are accounted for. They argued that a risk-free rate should be used for silviculture investments, and recommended a discount rate of between 3 and 5%.

The Ministry of Forests uses a 4% real rate of discount for public sector forestry investment analysis. The discount rate, whether public or private, is a “real” discount rate. This means that it does not include any inflationary expectations. Inflation is “netted out” of a real discount rate since it is assumed to affect both costs and prices equally over time.

Whatever discount rate is selected, it must be used consistently for all silvicultural treatments. For example, although a lower discount rate would “improve” the economics of juvenile spacing, it would also reduce the benefits derived from commercial thinning. The discount rate is clearly a two edged sword.

The importance of sensitivity analysis

Sensitivity analysis is an important analytical method used to evaluate the effects of risk and uncertainty in economic analyses. Sensitivity analysis involves re-calculating the site value of a silvicultural treatment using a range of values around key factor assumptions. Key factors in an economic analysis include, future revenue, harvest cost, milling costs, silviculture costs (regeneration, tending, protection, administration) and investment period (rotation length).

For example, a sensitivity analysis of future harvesting cost would involve repeating the economic analysis using harvesting costs that are slightly higher and slightly lower than the expected value. The usual approach is to test values within plus and minus an arbitrary percentage (e.g. 10%) of the expected value. The sensitivity analysis is performed while keeping all other key factors constant.

The three site values from the sensitivity analysis are then compared; large differences indicate that site value is “sensitive” to small changes in harvesting cost. Sensitivity in one or more key factors suggests that the economic analysis is not robust, and may lead to errors of interpretation. The outcome of the sensitivity analysis will determine whether all input values and assumptions should be re-evaluated.

Forest estate models
Source: Stand Density Management Guidebook (Draft), BCFS, 1997

Forest estate models are useful for projecting the impacts of stand management activities on the forest inventory over time. They have evolved over the past thirty years in parallel with the evolution of computing technology. Modelling forest estates involves manipulating large amounts of data. The sophistication of the model reflects the detail that can be incorporated into the data set.

Two types of forest estate model are available; simulations models and mathematical programming models. Both are used to determine the impact of stand density management activities on the stock and flow of harvestable timber, and on the achievement of other non-timber objectives. The issues of data quality and reasonable assumptions are important considerations. It is usually not the model which determines the utility of the answers.

Simulation models

Simulation - based forest estate models operate on the principle of achieving pre-determined levels of outputs for flows and stocks of timber, and non-timber resources. They can also incorporate risk in defining the success of outcomes of various activities being modelled. Unlike mathematical programming models, simulation models do not rely on a specific algorithm. Rather, they incorporate a wide variety of mathematical relationships, providing considerable flexibility of application.

Mathematical programming models

Mathematical programming models have their roots in the fields of engineering, operations research, medical research, and defence. They are widely used to solve transportation network problems, warehouse and inventory control problems, product distribution and sales problems, and in a variety of military applications. Their use in forestry is a relatively small segment of their application throughout the world.

Linear programming algorithms are the most common applications used for forest estate modelling. Linear programming is a method used to allocate limited resources to competing activities in an optimal manner. Although there are important assumptions regarding their use, linear programming offers considerable flexibility in applications such as forest management problems, harvest scheduling, silviculture planning, and economic analysis.

Economic analysis tools

Economic analysis tools are simply computerised equations, or calculation templates that incorporate economic principles for solving specific questions related to the worth of a silvicultural endeavour. Several of the models incorporate some of their capabilities to provide stand or forest level economic analysis.

For example, TIPSY allows the user to calculate the present value or site value of a juvenile spacing treatment. WOODSTOCK, a forest estate model, has the capability to account for production costs and the economic operability of any management activity. Most of the decision support models listed in Tables 2 and 3 can produce input to an economic analysis.

Tables 2 and 3 provide a brief description of commonly available stand and forest level analysis tools which may be used to analyse the effects of stand density management treatments. The list is not exhaustive, and neither the Working Group nor the Ministry of Forests advocate using any particular system, listed or otherwise. However, planners and silviculturists are encouraged to use proven decision-making support tools in their work.

Table 2. A list of commonly available, stand level decision support models

Tool	Owner	Description	Comments
FINSIL3	MacMillan Bloedel Ltd. Vancouver (public domain)	Spreadsheet program for financial analysis of silviculture treatments	Based on data obtained in mid to late 1980s, can easily be updated with new data
Stand Density Management Diagrams	BCFS, CFS UBC Vancouver and Victoria	A diagram which graphically displays the relations between (variously) volume, basal area, diameter, height, trees per hectare, percent site occupancy, mortality etc. Gingrich-style diagrams are one example.	Have been constructed in B.C. for lodgepole pine, white spruce, and interior Douglas-fir. Useful for illustrating relationships, however, similar and more information can be obtained from use of a growth and yield model.
PROGNOSIS	BCFS, Victoria	Stand Prognosis Model--growth and yield model for single and mixed species, even and uneven-aged stands	Part of a family of models which allows analysis of economics, pests, tree crowns and stand canopies. Calibrated for 14 regions of the US. Being calibrated by BCFS for B.C. interior species, starting in the Nelson Region.
PRUNSIM DF PRUNE	Forest Resource Systems Institute, Florence, Alabama	Spreadsheet program which estimates the financial return from pruning coastal Douglas-fir stands	Helps determine how many and which trees in a stand should be pruned. Calibrated for Southern Oregon.
SPS	Mason Bruce and Girard Ltd.	Stand Projection System/Forest Projection System--growth and yield model for single and mixed species; even- and uneven-aged stands	Some calibration for B.C.
FPS	J. Arney, Oregon, U.S.A.	Stand Projection System/Forest Projection System--growth and yield model for single and mixed species; even- and uneven-aged stands	Some calibration for B.C.
STIM WINSTIM	CFS, Victoria	Stand and Tree Integrated Model--growth and yield model	Also projects the growth of spaced and thinned stands. Calibrated for hemlock in B.C. and Pacific Northwest.
TASS	BCFS, Research Branch	Tree and Stand Simulator--biologically based growth and yield model for even-aged pure-species stands. see TIPSY	Calibrated for most even-aged stands of pure coniferous species of commercial importance in coastal and interior BC forests. Part of the SYLVER family of models.
XENO	MacMillan Bloedel Ltd., Nanaimo	A distance dependent stand growth model capable of growing single or mixed species under both natural and managed regimes.	Model simulates development of Douglas-fir and Western Hemlock, also allows for economic analysis in consideration of wood quality attributes.
SYLVER	BCFS, Research Branch	A System of models which evaluates the impact on Yield, Lumber Value and Economic Return.	
TIPSY	BCFS, Research Branch	Table Interpolation Program for Stand Yields--retrieves and interpolates stand yield information from a database generated by SYLVER	TIPSY is the Windows system which generates tables for standing yield (including stand and stock tables), mortality, snags, products (logs, lumber and chips) and economic return. Repression has recently been added for lodgepole pine.

Table 3. A list of commonly available forest estate models.

Tool	Owner	Description	Comments
ATLAS	UBC, Vancouver	A Tactical Landscape Analysis System--multiple rotation, spatially explicit, block scheduling timber supply simulation model.	Also performs road network analysis
CASH_FM	Timberline Forest Inventory Consultants Victoria	Continuous Harvesting and Forest Management--timber supply simulation model.	Approximates spatial harvest restrictions. Good for strategic-level analysis.
FSSIM	BCFS, Timber Supply Branch	FS Simulator--timber supply simulation model	Approximates spatial harvest restrictions. Good for strategic-level analysis; lacks economic analysis capability.
SIMFOR	UBC, Vancouver	Simulates the effects of forest management and stand development, predicts landscape composition, ecosystem pattern, and habitat distributions for selected species.	Landscape size may vary from 5 000 to 50 000 hectares.
TREEFARM	Stirling Wood Group, Victoria	Timber supply simulation model.	Approximates spatial harvest restrictions. Good for strategic-level analysis.
WOODLOT	BCFS, Resource Tenures & EngineeringBranch	Simulation model which finds the maximum single even-flow harvest level for a planning period.	Used for AAC determination for woodlots in B.C. Will receive yield projection output directly from TIPSY and VDYP stand yield models.
COMPLAN	Simons - Reid Collins, Vancouver	Forest estate simulation model for timber supply and forest estate activity planning.	Flexible data input structures, allows for explicit recognition of spatial constraints and objectives, also considers some economic issues.
OPTIONS	D.R. and Associates, Nanaimo	Forest estate simulation model for timber supply and forest estate activity planning.	
WOODSTOCK	REMSOFT, Inc. Fredericton	Flexible Forest Modelling System--timber supply model which allows the use of either simulation or linear programming.	Allows the analysis of random events (such as fire). Allows for economic analysis of forest level outputs.

Predicting future timber values
Source: Stand Density Management Guidebook (Draft), BCFS, 1997

Introduction

Forecasts of future product market conditions are necessary in order to evaluate the economic efficiency of stand density management investments. Because the return on most investments will not be obtained for 40 to 100 years, these forecasts are fraught with uncertainty. A clear statement of the the future price assumptions used is therefore necessary to allow for a critical review of the results of the analysis.

This section discusses the factors which may influence future real log and end product prices, and provides a summary of research into the potential for real price increases. It concludes with recommendations on future price assumptions for stand density management investment analysis.

Timber price increases

Future timber prices depend on the answers to two fundamental questions:

1. Will the factors that led to recent price increases for old growth timber also influence the future prices of second growth timber?
2. Will stand density management practices in second growth stands result in timber and wood characteristics similar the those of old growth stands?

It is rather difficult to provide substantive answers to these questions, however evidence suggests that the future will not be a reflection of the recent past.

Forecasts of future timber scarcity have led many observers to conclude that timber resources will experience real price increases with respect to other commodities over time. Changes in the real price of a commodity is an indicator of its relative scarcity. Increasing prices are associated with increasing scarcity and decreasing prices indicate decreasing scarcity.

The study of resource scarcity by Barnett and Morse (1963) examined prices and costs for the U.S. agriculture, minerals, forestry, fishing, and total extractives sectors using data collected by Potter and Christy (1962) for the period 1870 to 1957. With the exception of the forestry sector, Barnett and Morse found that the real price of natural resources did not increase over the period examined,

Manthy (1978) updated the Potter and Christy data to the early 1970's and confirmed Barnett and Morse's results. However, Manthy observed a significant change in the trend of forest product prices after 1950; from 1950 to 1970 real prices remained essentially stable.

Sedjo and Lyon (1990) examined price trends since 1970 and noted significant real increases in timber as well as most other natural resource prices during the 1970's. However, during the early 1980's real timber prices fell again to the levels of the 1950-70 period, and then remained stable. Sedjo and Lyon also concluded that the timber price trends of the post-1950 period were fundamentally different from earlier periods.

In the early 1990's sharp increases in timber prices were again experienced as North America recovered from an economic recession, and demand increased for timber products. At the same time, land-use decisions in the U.S. Pacific Northwest region resulted in the reservation of large areas of forest land for the protection of the northern spotted owl. Since 1990, timber prices have fluctuated wildly, a trend more characteristic of short-term adjustments in timber supply problems than of a return to rapid, long-term price increases.

Factors which tend to moderate timber scarcity include:

1. Technological changes which increase resource-use efficiency; for example, the development of saws with narrower kerfs and improved cutting patterns increased lumber recovery during the 1970's and 1980's.
2. Substitution of previously unused timber resources which compensate for shortages of conventional timber resources; for example, the substitution of hardwood chips and the production of wafer board for softwood veneer and plywood. Continued acceptance of substitute materials in products previously manufactured from old growth timber will reduce the economic impact of old growth timber scarcity.
3. Development of substitute products which replaces conventional timber products; for example, the manufacture of engineered construction products such as composite wood I-beams may replace much of the demand for large dimension, structural lumber (e.g. 2x10s and 2x12s) for certain applications.
4. Substitution of non-timber materials which replaces similar timber products; for example, the use of steel framing studs for light duty construction is becoming more common as the price of lumber increases relative to the price of steel.
5. Responses in timber supply to actual or threatened scarcity; for example, as the price of timber rises due to scarcity, manufactures may increase the supply by a variety of means. Firstly, improved milling utilization may decrease the marginal log size, thereby resulting in greater wood recovery from each stand. Secondly, improved logging utilization may result in the harvest of previously unprofitable stands, thereby expanding the operable harvest base. Thirdly, increasing timber prices may make site productivity-enhancing silvicultural treatments more attractive, thereby increasing the rate of production from a fixed land base.

It is unrealistic to expect any of these factors to completely off-set future real price increases. For example, it is more likely that technological advancements will eventually experience diminishing marginal returns in the sawmill and woods sectors since there is only so much fibre contained within a log and only so much timber produced on a site. However, in view of the combined potential of all of moderating factors, caution is advised in assuming rapid, sustained, long-term real price increases.

Projections of future timber price increases take some of these factors into account (Sedjo and Lyon 1990; Dykstra and Kallio 1987). Both studies are based on models of world timber supply and demand. Sedjo and Lyon (1990) predict in their base case scenario that the price of timber would increase over the period 1988-2000 at an annual rate of 0.2%. In a high industrial wood-demand scenario they projected an annual real price increase of 1.2%.

Dykstra and Kallio provide forecasts for different areas of the world and differentiate between the price for conifer and non-conifer species, and between the prices of sawlogs and pulp logs. They project an annual rate of real price increase of 0.3 to 5.9% for conifer sawlogs over the period 1980 to 2000, depending on the area of the world in which the timber is harvested.

In a study commissioned for Forestry Canada, H.A. Simons Strategic Services Division and Cortex Consultants Inc. (1993) reviewed historical log, lumber and chip prices in British Columbia. Although only a small proportion of the total B.C. production of logs is valued on the Vancouver log market, they found that over the last two and a half decades coastal log prices have increased on average by 0.3% per year. However, the price increases varied considerably by period and by species. For example, real prices increased during the 1970's by as much as 3.9% per year.

Vancouver log market prices, as well as those used to calculate provincial stumpage are still influenced significantly by international log and wood product prices. The authors (H.A. Simons and Cortex 1993) developed predictive equations to forecast log price increases for 4 coastal species groups. Table 1 presents species/price expectations for the period 1990-2040.

An analysis by Feltham and Messmer (1996) reviews a number of studies of historical sawn wood prices, projected future price changes, and the use of a time series to calculate historical real price changes and an index of wood quality change for B.C. and Canada. Their data represent total sawn wood timber volume and value, by species group, for B.C. and Canada from 1918 to 1990.

Table 1 Real price increase forecasts for logs from the coastal region [1].

Forecast period (years)	Douglas fir	cedar	hemlock	true firs
	species (% per year)			
1990-2000	1.4	3.8	0.2	0.8
2000-2010	0.1	-0.7	-0.6	-0.2
2010-2020	0.4	0.5	0.1	0.3
2020-2030	0.1	0.3	0.1	0.1
2030-2040	0.1	0.3	0.1	0.1
Average	0.4	0.9	0.0	0.2

Source: H.A. Simons Strategic Services Division and Cortex Consultants [1993].

[1] These data are presented only as an example of forecasts typical of the range of values found from a number of recent analyses. They should not be considered the only, or the most accurate forecast of timber prices increases available. See also Feltham and Messmer, 1996.

Feltham and Messmer (1996) found the volume-weighted, average, real softwood prices in B.C. during the period 1926 to 1990 increased 0.53%/yr. Only two B.C. species experienced a decline in real price. In Canada the average annual rate of increase was 0.24%; no species declined in real price over the period. The highest rate of price increase in Canada during this period was recorded for was hemlock, which increased at an average rate of 1.56% per year. The largest decline was recorded for Ponderosa pine, which changed in real terms at a rate of -0.32% per year over the period.

The real price trends for the period 1965 to 1990 differ from those for the period 1926 to 1990. For example, the volume-weighted average of softwood species prices in B.C. for 1965 to 1990 was only 0.29%, with six B.C. tree species exhibiting declining prices. Canadian real prices declined by an average of 0.24% each year during this period, with five tree species showing an average annual decline. The highest annual rate of price increase in B.C. during this period was 2.2% for yellow cypress, compared to the greatest decline of -1.14% for lodgepole pine. The highest Canadian real price rate increase was only 0.44%/yr, for hemlock, compared with the greatest decline for lodgepole pine of -0.34%/yr.

Historical and projected price growth rates vary among studies. Variation may be attributed to the different time periods over which the rates are calculated, as well as the different timber products and regions on which they are based. Despite this variation, however, Feltham and Messmer (1996) found consensus on expectations that future prices will increase at a decreasing rates for timber supply regions in B.C., the Pacific Northwest and the Southern U.S., for virtually all species and timber grades. There was no agreement amongst the studies on whether the prices of higher quality species and grades would change at a different rate (faster or slower) than prices for lower quality species and grades. The historical rates of price increase ranged from a high of 3.45%/yr for Douglas fir Grade 1 logs from the 1930s to the 1990s, to a low of -1.6%/yr for hemlock lumber for the period 1965 to 1990.

A species effect on wood quality index was also calculated in the Feltham and Messmer analysis. From 1925 to 1990 the annual rate of decrease in wood quality attributable to the change in species composition averaged 0.14 % for B.C. and 0.12% for Canada. The Haley and Constantino study (1988), on which this index was based, used log data from the Vancouver Log Market and found an average annual decrease of 0.28%. The divergence between the two studies may be attributed to technological change and its role in dampening the transmission of species composition effects from the log market to the lumber market. Substitution between species may also account for some of the divergence.

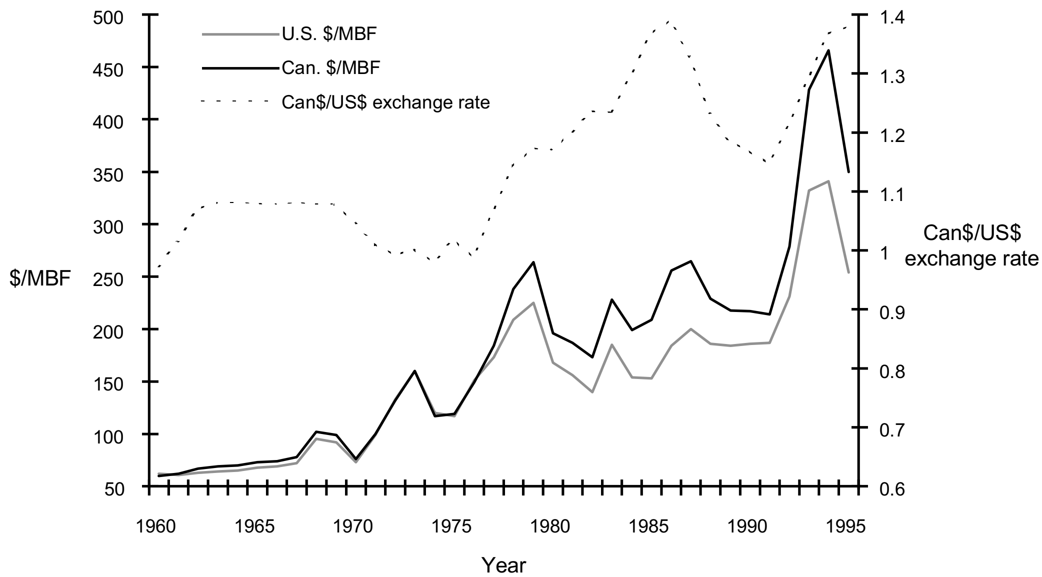
End-product prices

The price of lumber is determined by the interaction of international lumber supply and demand forces. The market for lumber is relatively competitive, and includes many buyers and sellers, with firms acting as price takers. The demand for lumber is considered to be a derived demand since the product is not directly consumed by households, but rather it is consumed indirectly in the production of housing and other products. Thus, the demand for lumber is derived from the demand for finished goods such as housing.

The U.S. is the major market for lumber in North America, so lumber prices are in U.S. dollars. The price Canadian producers receive is therefore determined by international market factors plus the current Canada/U.S. exchange rate. The difference in the exchange rate tends to amplify changes in the U.S prices. For example, Figure 1 illustrates the general trend for rising lumber prices over the period 1960 to 1995[2] relative to changes in the Canada/U.S. exchange rate.

The effects of inflation must be removed in order to determine if a real price increase has occurred. This can be done by expressing real prices in constant dollars for a selected year (the base year), to which the prices in other years are adjusted using a suitable price index.

Figure 1 Trend in lumber prices (western Spruce-Pine-Fir, kiln dried, standard & better, 2x4, random length lumber).



The prices in Figure 1 were therefore converted to Canadian $/thousand board feet (MBF), and adjusted using the consumer price index (CPI) for Canada to reflect constant 1995 dollars. The results of the conversion are shown in Figure 2. Note that real price fluctuated between $226-594/MBF with an average of $380/MBF over the period shown. No obvious trend is indicated by the diagram although it does show the extreme volatility of lumber prices over time. This volatility would be even greater if monthly prices were graphed. The lack of any trend in the graph indicates that although, on average over the period shown, the nominal prices have increased with inflation, there has been little or no change in real prices.

[2] Based on average annual prices of kiln dried, standard and better wester spruce-pine-fir 2x4 random length lumber (source: Random Length Publications Inc., various years).

Figure 3 shows the fluctuations in the price of structural dimension lumber in constant 1995 Canadian $/MBF for western spruce-pine-fir (SPF) kiln dried, standard and better, random lengths lumber. Not surprisingly the price trend for each dimension tracks one another quite closely. This is more clearly demonstrated in Figure 4 which shows the variation in the ratio of the price of western spruce-pine-fir for each dimension relative to the price of 2x4s.

The ratio for 2x6 and 2x8 lumber fluctuated around 1.0 and averaged 0.97 and 0.99 respectively over the period shown. The ratio for 2x10 lumber varied between 1.1 and 1.3 with an average of 1.19 over the period shown.

Figure 2. Trends in real lumber prices in constant 1995 Canadian dollars (western Spruce-Pine-Fir, kiln dried, standard and better, 2x4, random length lumber)

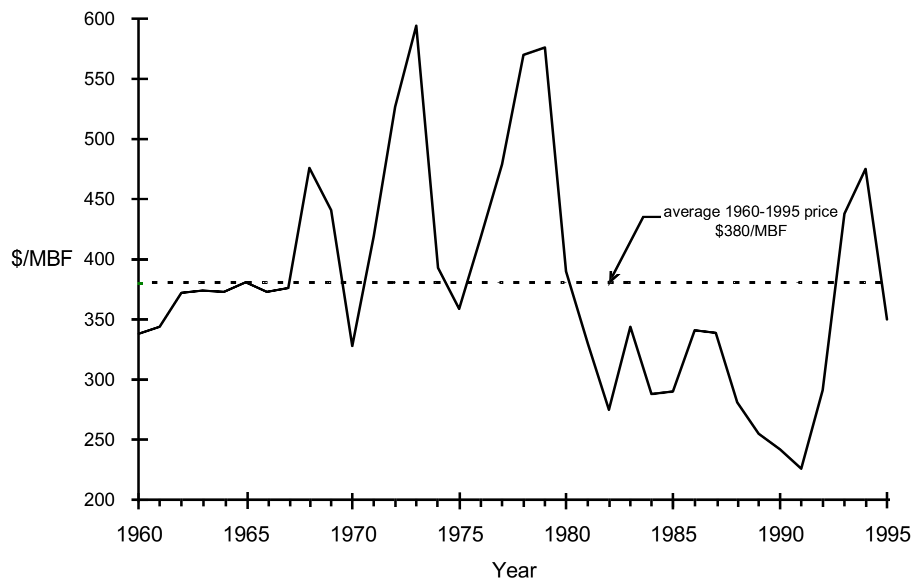


Figure 3. Trends in lumber prices by dimension (1995 Canadian $/MBF).

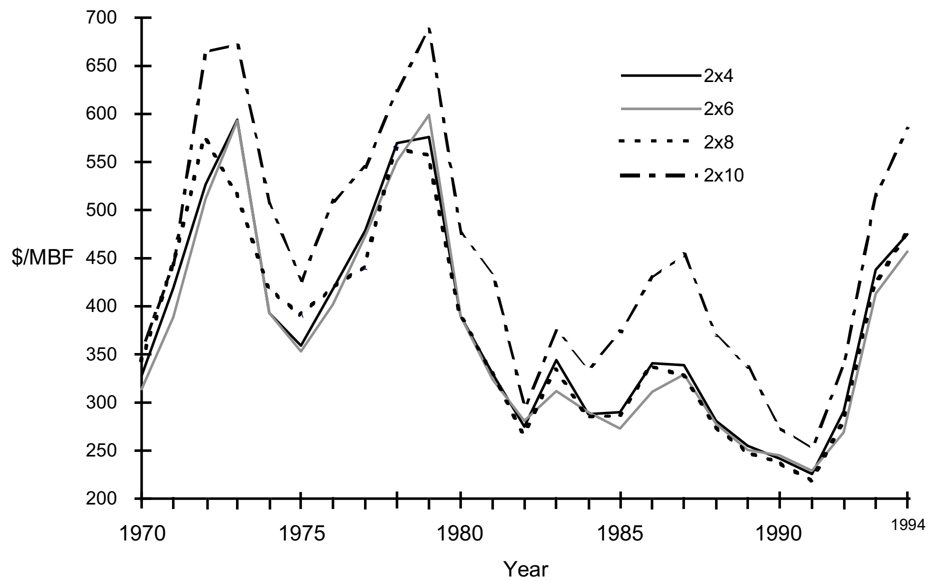
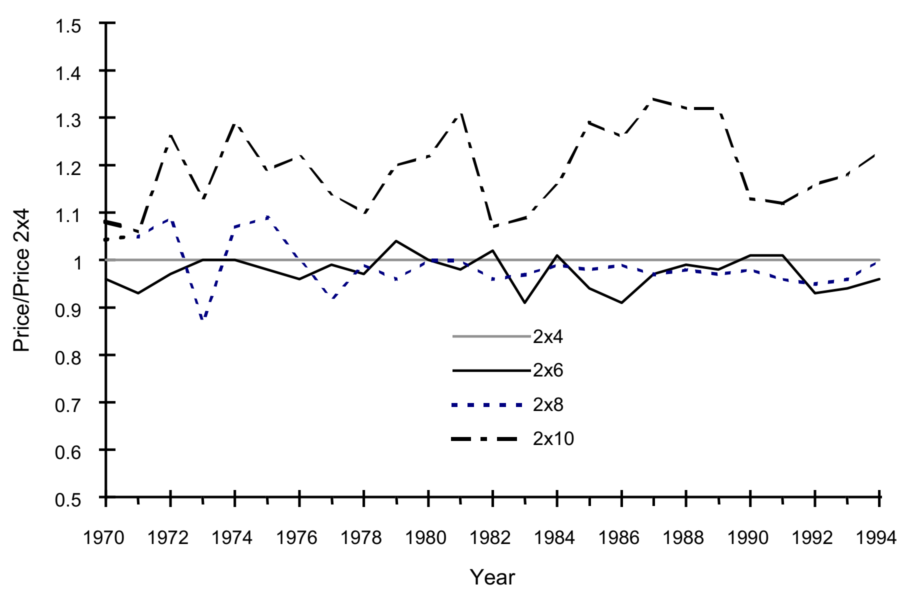


Figure 4. Ratio of price of western SPF kiln dried dimension lumber relative to the price of 2x4 lumber

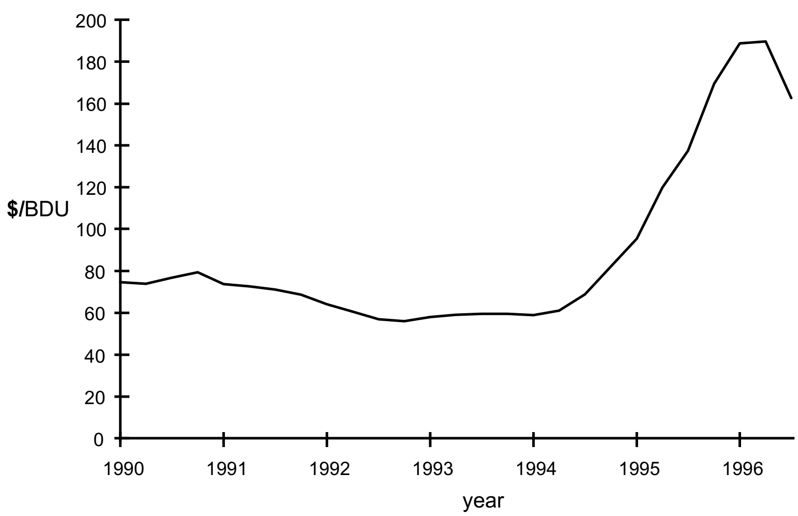


Wood chip prices

The Ministry of Forests Revenue Branch collects data on private sector sales of residual wood chips from sawmills to pulp mills in the interior of British

Columbia.[3] The delivered chip prices in bone dry unit (BDU) are adjusted by the estimated freight haul cost to produce an estimate of the value of the material at the sawmill gate, for each appraisal point in the interior. These average market values are published quarterly and represent the average value over the preceding twelve month period. Figure 5 shows the trend in whitewood chip average market values for the period January 1990 to June 1995.[4] Chip prices were quite stable until the end of 1994 when price began to increase sharply. These price increases may be attributable to a robust pulp market and the rapidly increasing price of market pulp, coupled with an increasing shortage of chip supplies in the interior regions. However, these large price increases are likely unsustainable in the long-run as there will be an eventual down-turn in the price of market pulp, and the probability of a chip supply response to the current high chip prices.

Figure 5. Interior average market values for whitewood chips 1990-1995 (constant 1995 dollars per bone dry unit).



The graph in Figure 5 indicates that the rapid increase in the average market value of chips had peaked at the beginning of 1996. On the other hand, prices may not return to the range experienced prior to 1995. Some studies have concluded that the market for residual wood chips in the interior has not produced competitive prices due to the potential oligopolistic power of pulp mills relative to sawmills (for example, see Nelson *et al*., 1994).

What means do we have then for estimating a long-run real wood chip price? Figure 6 illustrates the real price trends for North American wood chips over the

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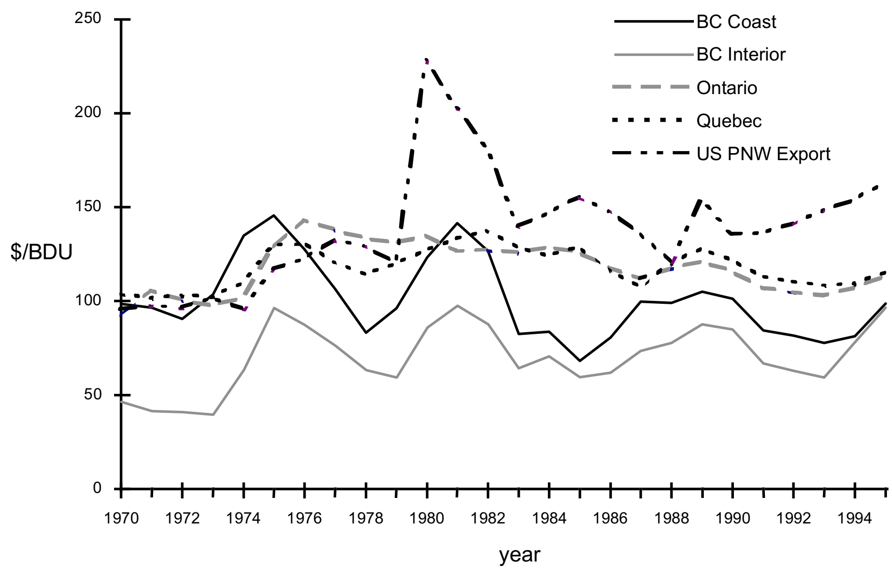
3 Thus they exclude infra-firm transfers of wood chips within vertically integrated firms.

4 Prices graphed are the arithmetic average of all appraisal point average market values as published by the Revenue Branch after conversion to constant 1995 dollars. Whitewood refers to all conifer species except western redcedar.

period 1970-1995. The original data comes from RISI (1994) and was expressed in nominal Canadian dollars per tonne for the Canadian markets, and in nominal U.S dollars per short ton for the U.S. Pacific Northwest export market. Note the data for 1994 and 1995 are projections. The data was converted to dollars per BDU and then to constant 1995 Canadian dollars per BDU using the CPI and the Canada/U.S. exchange rate where appropriate.

Figure 6. Trends in wood chip prices in North America (constant Canadian 1995 dollars per bone dry unit)



The average price/BDU for wood chips over the period 1970 to 1995 was $104.76 for the B.C. coast, $73.21 for the B.C. interior, $122.02 for Ontario, $122.25, for Quebec, and $143.58 for the U.S. Pacific Northwest export market.[5] The price trends and averages for Ontario, Quebec and the U.S. Pacific Northwest are similar and could indicate that the world wood chip price level is currently between $110 and $130 per BDU (f.o.b. mill). Thus, the assumption of a long-run average price for whitewood pulp chips in B.C. of $110/BDU does not appear unreasonable.

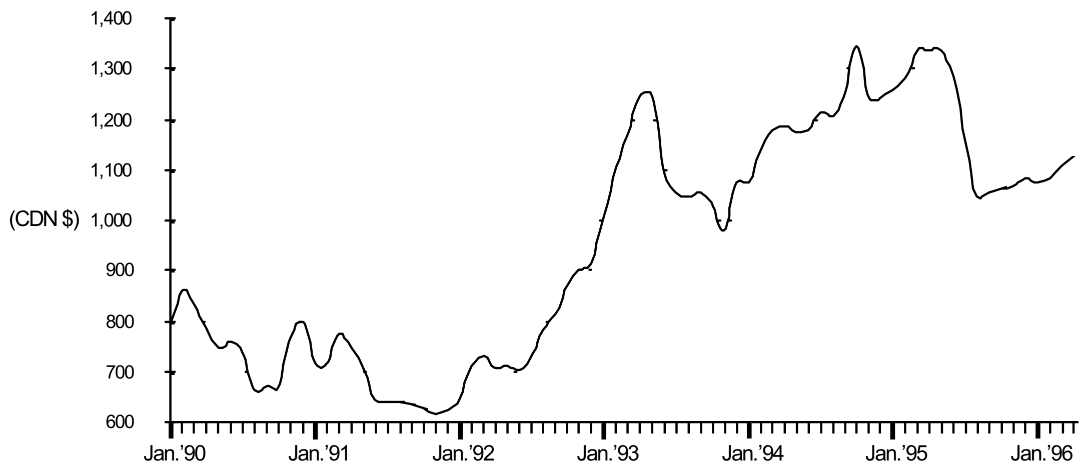
The B.C. interior average market values of western red cedar wood chips has ranged from $10 to $19 per BDU and has not been affected by the upturn in pulp market prices. Cedar chips are viewed as an inferior product by pulp mills, so it is unlikely they will increase in real value in the foreseeable future. Thus, the assumed long-run price for cedar chips is $15/BDU.

[5] Prices were f.o.b. mill for all regions except the U.S. PNW which was f.a.s.

Japanese Lumber Markets

While most of the lumber produced in the interior region of the province is exported to the U.S., lumber sales from the coast region are diversified to a much greater degree throughout the pacific rim countries, notably Japan. One of the major coastal timber products now sold there is hemlock squares (cants usually of 3-9/16"x3-9/16" dimension). Figure 7 shows the real price of hemlock squares over the period January 1990 to April 1996.

Figure 7. The real price of hemlock squares over the period January 1990 through April 1996 (delivered price/MBF).

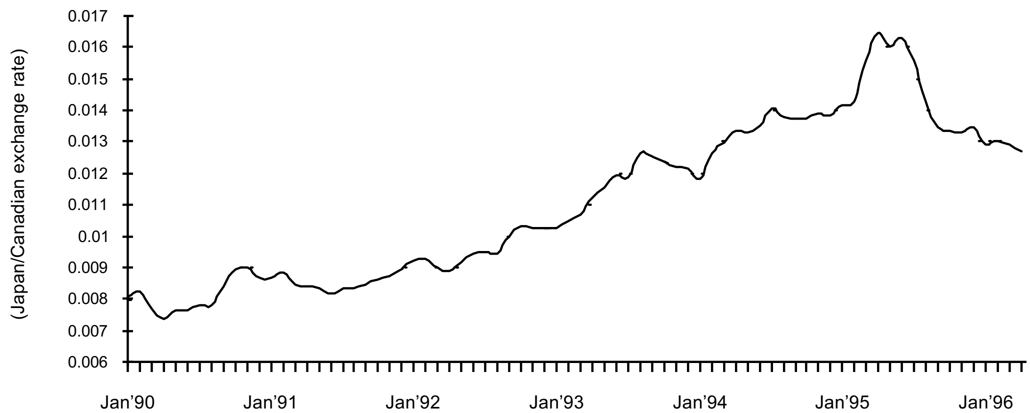


Note the prices are delivered (c.i.f.) whereas the lumber prices reported in previous illustrations were f.o.b. sawmill prices. The graph indicates a substantial price increase starting around April of 1992. One of the reasons for this increase was a substantial rise in the value of the Japanese yen relative to the Canadian dollar. Figure 8 shows the Japanese/Canadian exchange rate over the same period. Note the value of the Yen started to climb rapidly relative to the Canadian dollar starting about April 1992. The pattern over time for the price of hemlock squares shown in Figure 7 closely follows that of the exchange rate shown in Figure 8.

If one considers the price rise of April 1992 to be the result of changes in the exchange rate, then it is reasonable to assume that future price may also be linked to future increases in the value of the yen relative to the Canadian dollar. However, it is extremely unlikely that the exchange rate will remain as high as the peak shown in Figure 8.

While many economic observers believed the yen was undervalued during the 1980s, few believe it is so today. The peak in the exchange rate shown in Figure 8 has been attributed by some to the sudden liquidation of foreign reserves by the Japanese government and industry in order to rebuild after the devastation of the 1995 earthquake.

Figure 8. **Japanese/Canadian exchange rate over the period January 1990 through April 1996 (based on the Japan noon spot rate; in Canadian dollars).**



A final note concerns the cost of manufacturing hemlock squares, relative to that of dimension lumber. The lumber recovery factor (LRF) for logs sawn into squares is significantly lower than for the production of dimension lumber from the same logs. Thus, more raw material/MBF is required, resulting in a higher milling cost for producing squares.

Conclusions and recommendations

Time in and of itself has no effect on prices, and past prices do not dictate what future prices will be. Market supply and demand forces, which change over time, are what cause prices to change. Use of simple trend models to predict future prices assumes that forces of supply and demand which caused the past price changes are closely correlated with time and that this correlation will continue into the future. This assumption is simplistic, and warrants caution in the use of models based on similar logic.

Long-run real log price increases

Given the factors which mitigate against real price increases, it is appropriate to select a conservative estimate of future real price increases. The estimates presented in Table 1 are examples of those typical within the range of most estimates. They are not unreasonable, especially if limited to the 50 year time period shown.

Long-run real lumber and chip prices

The real lumber and wood chip prices presented in Table 2 may provide reasonable long-run estimates (Stone *et al.*, 1996). The long-run real price of 2x4 lumber for each species is the average for the periods studied, while the price for other dimensions is a function of the 2x4 price and the average price ratio of dimension lumber to 2x4 lumber.

Table 2. Default lumber and wood chip prices used in the TIPSY ECONOMIST (constant 1995 dollars)

Species	Lumber				
	2x4	2x6	2x8	2x10	Wood Chips
		($/MBF)			($/BDU)
Coastal Douglas-fir	455	460	455	560	110
Lodgepole Pine	380	369	376	452	110
Western Hemlock	406	406	414	491	110
Sitka Spruce	380	369	376	452	110
Western Red Cedar	482	482	583	583	15
White Spruce	380	369	376	452	110
Interior Douglas-fir	426	430	439	554	110

Source: Stone *et al.*, 1996.

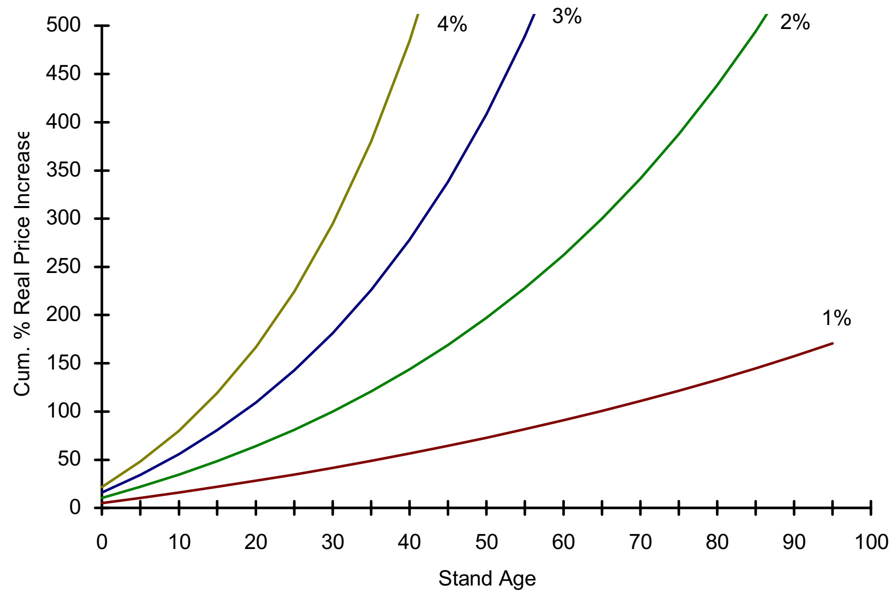
Real per annum price increases - a word of caution

Given the lack of any clear trend in past real lumber prices (as indicated in Figure 2), and the likelihood of only modest real price increases for logs in the future, caution is warranted in making future value assumptions when evaluating the economic efficiency of silvicultural investments. For example, Figure 9 illustrates the cumulative effect of annual real price increases of 1%, 2%, 3%, and 4%. If these annual price increases were compounded over a period of 75 years, as they might be in an analysis of juvenile spacing for instance, the resulting cumulative increase in timber value would be 111%, 342%, 818% and 1,795%, respectively.

The significance of these extremely high future values is considerable in the calculation of net present value or site value of a stand density management investment analysis.

The compounding effect of an assumed annual price increase can be reduced by limiting the period over which the compounding takes place. For example, an assumption of a 1% per annum real price increase over the first 25 years with no real price increase thereafter results in a cumulative real price increase of only 28%.

Figure 9. **Cumulative real price increase resulting from 1%, 2%, 3% and 4% annual real price increases.**



Glossary

ageclass distribution
A histogram of the area occupied by (timber volume represented by) distinct age classes (usually 5 or 10 year intervals) of growing stock within an area of forest land.

biodiversity objective
A type of management objective aimed at preserving or enhancing the presence and richness of species of plant, animal, and other living organisms in all their forms and levels of organization (genes, species, communities), including the evolutionary and functional processes that link them.

biogeoclimatic subzone
A geographic area having similar patterns of energy flow, vegetation and soils as a result of a broadly homogenous macroclimate, as categorized by the Biogeoclimatic Ecosystem Classification System of British Columbia.

chainsaw effect
A reduction in the top height of a stand resulting from improper crop tree section during juvenile spacing or commercial thinning; this effect lowers the timber production capacity of the residual stand.

close utilization
Harvesting the maximum volume of timber from a stand, as measured by the minimum stump height, stump diameter, and top diameter of each tree harvested.

clumping
A spatial pattern of tree establishment where small groups, or clumps of trees are distributed throughout a stand; as opposed to random or even distribution of single trees.

commercial thinning
A partial cut in stands where the timber removed is sold; conducted in even-aged stands, provides an interim timber harvest during a stand rotation, and maintains or redistributes stand growth without significantly reducing the production of the residual stand.

community watershed
A natural drainage area above the most downstream point of water diversion on a stream; water use is for human consumption and is licensed under the *Water Act* for either a waterworks, or a domestic purpose if the license is held by or is subject to the control of a water users' community incorporated under the *Water Act*; or an area designated as a community watershed under the *Water Act*.

crossover volume response
A timber volume response to thinning (pre-commercial or commercial) which eventually exceeds the volume production of a similar, unthinned stand.

crown class
A relative measure of the size and position of a tree's crown within the canopy of a stand; numerical or subjective categories of crown size and position have been defined (e.g. dominant, co-dominant, intermediate, overtopped).

crown closure
The point during the growth of an even-aged stand when the branches of adjacent trees make physical contact; a continuous canopy of tree foliage.

crown competition
The process of branch and foliage growth of adjacent trees which results in an uneven interception of available sunlight; a measure of the foliage surface of tree crowns within a stand canopy, calculated as an index of the relationship between stand density, tree diameter and area of ground surface covered by foliage.

culmination of mean annual increment
M.A.I. is a measure of the average annual change in volume over a specific time period (e.g. 5 years); culmination occurs during the period of time when the m.a.i. reaches a maximum for a specific stand, and before it begins to decrease.

decay inoculum
The infectious spores, mycelia, or micorhizae of decay-causing fungi.

diameter at breast height
The bole diameter of a tree measured at 1.3 metres above the point of germination ; DBH is the commonly used, abreviated form.

discount rate
The rate of interest used to measure future expected costs and revenues in today's dollars; the rate of interest used for discounting is a function of social time preference, the opportunity cost of capital, and investment risk.

dominant
A qualitative measure of the size and height and of a tree's crown; a tree whose crown is receiving full light from above and partly from the sides, is larger than the average size of crowns in the stand, is well developed, although somewhat crowded on the sides.

economic efficiency
The level of production of economic goods and services with the lowest level of inputs (labour and capital) capable of producing only the amount of outputs demanded in the marketplace, at the highest attainable level of profit; a measure used to determine the optimum combination of inputs required to produce goods and services that meet both cost minimization and profit maximization objectives.

economic rotation age
The point in time (stand age) during the growth of a stand when the rate of increase of the net value of the stand begins to decline; the economic rotation age generally occurs before the physical rotation age (culmination of mean annual increment).

espacement
The number (trees/ha) and distribution (stocking) of planted or naturally regenerated seedlings; often expressed as square spacing of planted trees or average inter-tree distance.

establishment density
The number of trees per unit area at the completion of planting, or the total number of surviving trees per unit area at the conclusion of a specified period of natural regeneration.

expected value
A value which will occur with some known level of probability in a future time period.

feasibility analysis
A method used to determine the net benefits from a given set of management activities; the benefits may be measured in either volume and/or value terms and the activities may occur in present and/or future time periods.

fire-origin stand
A replacement stand resulting from naturally occuring regeneration following the destruction of a previous cohort; usually consisting of tree species which rely on fire to regenerate.

forest estate model
A representation of the growth and natural dynamics of a pre-defined area of forest; used to simulate the effects of harvesting and silviculture on the long term availability of timber supply from defined forest areas.

forest level objectives
All definable timber and non-timber goods and services, values and activities for a specific bounded area of forest land over a specified period of time.

free growing stand
A stand of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, and other trees.

growth and yield model
One or more mathematical relationships (algorithms) between various tree and stand parameters, based on empirical data from stands of trees, which permit for the projection of various tree and growth characteristics over the expected life of a stand; usually allows simulation of various cultural inputs such as juvenile spacing, pruning, fertilizing and thinning.

harvest constraints
Limits imposed on a condition or activity within a forest estate; defined as part of an overall forest estate model; are usually defined by forest level objectives.

harvest scheduling flexibility
The relative variability permitted in the order and timing of stand harvest activities in a forest estate model; defined by the interaction between forest level objectives, harvest constraints, and the current and future conditions of the forest estate.

higher level plan
Higher level plans establish the broader, strategic context for operational plans, providing objectives that determine the mix of forest resources to be managed in a given area. They fall into two categories:

1. Plans that are directly enabled through Part 2 of the Forest Practices Code of British Columbia Act. These include objectives for the following:
   - resource management zones
   - landscape units
   - sensitive areas
   - interpretive forest sites, recreation sites and recreation trails.
2. Plans that are developed under non-Code legislation or policy. These include the following:
   - plans or agreements declared to be higher level plans by the Lieutenant Governor in Council (also referred to as Cabinet) or the ministers
   - plans formulated pursuant to section 4 (c) of the Ministry of Forests Act, which are designated as higher level plans by the district manager in accordance with direction from the chief forester
   - management plans, which may be designated as higher level plans by the chief forester for tree farm licences, and by the regional manager for other agreements under the Forest Act.

height-diameter ratio
The diameter (DBH) of a tree relative to its total height at a given age; a measure of tree slenderness and resilience to wind and snow pressures; an indirect measure of the previous crown volume of a tree.

height growth repression
A stand condition that occurs in stands established at high density (usually greater than 10,000 stems per ha.); results in a reduction in the rate of height growth of the stand compared to similar stands that are less dense; observed and documented in the species lodgepole pine.

hemlock square
A characteristic lumber dimension sawn for the Japanese export market; variable in dimension from 3.5 inches by 3.5 inches to 15 inches by 15 inches; a common end-product from coastal B.C. sawmill operations.

higher level plans
A plan pursuant to section 4(c) of the *Ministry of Forests Act* and designated as a higher level plan by the district manager in accordance with direction from the chief forester.

income distribution
The allocation and disposition of wealth among individuals, households, and businesses in an economy; policies and laws governing taxation and the collection of resource rents are designed to address issues related to income distribution in an economy.

inflationary expectations
The expected decline in the value of money over some future time period; determine the difference between the real rate of interest and the nominal (or money) rate of interest.

inter-generational equity
The distribution of resources and wealth between current generations and future generations of individuals; use and consumption of resources and creation of wealth affects the ability of future generations to consume resources and create wealth.

intermediate
A qualitative measure of the size and height and of a tree's crown; a tree whose crown is shorter than trees in the stand classed as dominant or co-dominant, but extending into the crown cover formed by codominant and dominant trees; receiving a little direct light from above but none from the sides; usually with small crowns, and considerably crowded on the sides.

inventory projection
A method for tracking the stock and state (timber volume and distribution of stand age classes) of an area of forest over time: forms the basis for virtually all forest estate models.

juvenile wood
Secondary xylem tissue produced by cambial regions that are influenced by hormonal activity in the apical meristem; is produced for approximately the first 5 to 25 years of growth for most temperate tree species; considered lower in quality than mature wood (unaffected by the apical meristem).

kerf
The width of a saw blade used for cutting logs or cants into boards; displaces a certain amount of solid wood and thus affects the amount of solid wood produced in boards from a log or cant.

landscape unit objective
A landscape unit is defined by the District Manager. It is generally an area of land op to 100,000 ha. in size delineated according to topographic or geographic features such as a watershed or series of adjacent watersheds. The District Manager must establish objectives for a landscape unit, and may vary or cancel an objective.

linear programming model
A method for determining an optimal level of output from an activity - the optimal level of output is determined by the availability of conditions and inputs required to perform activities defined in the model; often used to define the timing and quantity of harvest levels that can be obtained from a forest estate while maintaining the forest in a condition that provides for all other defined forest values.

lumber recovery
The ratio of the volume of sawnwood recovered from a log to the total volume of wood in the log.

management unit plans
A forest management plan approved under a tree farm licence, or a woodlot licence, usually in effect for a period of five years and specifies proposed management activities to establish, tend, protect, and harvest timber resources, and to conserve other resource values.

mathematical programming model
A model based on mathematical algorithms or sets of equations designed to solve a problem based on a pre-defined set of assumptions and starting conditions; a linear programming model is a type of mathematical programming model.

maximum density
A forest policy that defines the maximum number of free growing, well-spaced coniferous that must be present at a specified free-growing date in order for the stand to meet the legally required silviculture obligation. See Section 70(4)(f) of the *Forest Practices Code Act* .

mean annual increment
The arithmetic average annual change in the volume of a tree or stand from its establishment to a given point in time.

merchantability standard
The minimum top diameter, minimum diameter at breast height, and maximum stump height that defines a merchantable tree.

natural disturbance type
An area whose soil and vegetation is influenced by a natural disturbance regime.

net present value (NPV)
The sum of all discounted costs and revenues expected over the life of an investment; in forestry the investment period is usually the rotation length.

non-timber values
Dollar values and/or quantities of natural resources that are not priced or traded in markets, including wildlife, wilderness, scenic views, and the utility derived from a wide variety of outdoor activities.

oligopolistic
A market behaviour characterized by a few large firms acting as sellers of goods or services; characterized by demand conditions being affected by each firm's output decisions, resulting in a conscious interaction among firms, leading to a variety of forms of strategic behaviour in production and output decisions.

opportunity cost of capital
The amount a firm must pay to the owners of capital in order to attract the capital (or other factor of production) necessary to engage in the firm's business. The firm must pay the owners of the capital an amount sufficient to induce them to sacrifice the next best alternative use of the capital, which is generally the going market price of the capital, or other factor of production.

present value
The value of some future expenditure, revenue or future series of expenditures and/or revenues discounted at some rate to the value of them in the present period.

prime trees
The 250 trees of largest diameter in a stand as projected to a given point in time by a growth and yield model; the actual membership of trees classed as prime trees may change over time.

product values
The market values of end products produced or expected to be produced from the logs after a stand is harvested.

production economics
The theory of the behaviour and decisions of firms that produce goods and services demanded by consumers.

real price change
The percent change in market price of goods or services over some time period over and above any change in its price due to inflation; is a reflection of the change in the scarcity of goods or services over time.

resource management objectives
A statement of intent to ensure the maintenance or production of some level of timber and/or non-timber resources from the area of forest to which the resource management objective applies. The resource management objective may also be defined by a resource management zone, and the chief forester may designate a resource management objective and/or zone as a higher level plan.

riparian area
Also known as a riparian management area; an area of a width determined in accordance with Part 10 of the Operational Planning Regulation of the *Forest Practices Code Act*, that is adjacent to a stream or wetland or a lake with a riparian class of L2, L3, or L4, and consists of a riparian management zone, and depending on the riparian class of the stream, wetland, or lake, a riparian reserve zone.

rotation age
The actual or expected age of a stand when it is harvested.

sensitivity analysis
A method used to determine the relationships between measures and assumptions used in an analysis, and to determine the effects of changing the value of measures and assumptions on the results of an analysis; is usually conducted by recalculating an analysis a number of times each with a change in one measure or assumption at a time.

silviculture prescription (SP)
A site-specific plan that describes the forest management objectives for an area; must be consistent with any higher level plan that encompasses the area to which the prescription applies; identifies the method for harvesting the existing forest stands and a series of silviculture treatments that will be carried out to establish a free growing crop of trees in a manner that accommodates other resource values as identified; subsequent documents, including cutting authorities and logging plans, must follow the intent and meet the standards specified in the silviculture prescription.

simulation model
A representation of an actual biological system which operates on the basis of achieving pre-determined levels of outputs for flows and stocks of timber and non-timber resources; generally require a "starting point" or "seed" to define the initial conditions or state of the resources and activities being modeled.

site value (or soil expectation value)
The sum of the discounted values of all costs and revenues over an infinite series of investment periods (rotations) of equal length.

social welfare objectives
Government objectives which address the distribution of income or wealth in society; for silviculture in British Columbia, this has meant using silviculture activity as an economic development tool to provide employment in the forest; Government can distribute income to silviculture contractors by providing funds for stand density management activities; in this context it is important to distinguish between wealth generation and redistribution of wealth.

stand density management
Silvicultural activities which alter the quantity and distribution of trees in a stand including pre-commercial thinning (juvenile spacing) and commercial thinning.

stand density management diagram
A graphical depiction of the temporal relationships between stand density, top height, quadratic mean diameter, and mean tree volume; based on averages of the distribution of actual output of single species stand and stock tables from a yield projection.

stand management prescription (SMP)
A site-specific plan describing the nature and extent of silviculture activities planned for a free growing stand of trees to facilitate the achievement of specified or identified social, economic or environmental objectives.

stand table
A tabular display of the number of trees in a stand according to a classification system such as species, diameter at breast height, and height class.

stock table
The tabular counterpart to a stand table, which displays stand volume according to a classification system such as species and tree size or diameter class; common parameters are gross and merchantable volume.

stocking guide
Output from growth and yield projections in the form of a look-up table; displays average values of parameters such as tree volume, average diameter, and average height.

stocking standard
The recommended number of seedlings that should be planted per unit area: may also recommend the type of seedling or planting stock, when or how the planting should be conducted, and the types of sites suited to different stocking standards.

stump height
The height above ground of the remaining portion of the stem of a tree after it has been harvested; stump heights are regulated as part of the utilization standard.

substitution
A mixed species stand resulting from a one-to-one substitution of trees of a monoculture with trees of another species so the total stand density remains constant.

sunk cost
A cost that does not affect the decision to make a further or additional expenditure; an example of a sunk cost in forestry is the cost of planting in relation to a thinning investment; the planting cost does not affect the decision of whether or not to incur a thinning cost since the thinning cost is compared to a regime where no thinning takes place - in order to be comparable, both regimes must either assume a planting cost or no planting cost.

taper
The form factor of the stem of a tree, and the degree to which the stem shape resembles a cone or a cylinder. The degree to which a tree is tapered (i.e. conical as opposed to cylindrical) is affected by the density of the stand it grows in; the less dense the stand, the greater the amount of taper.

visual buffer
An area of usually mature, undisturbed forest or a topographic feature such as a hill that masks harvesting disturbances such as recent clear cut areas.

visual quality objective (VQO)
Defines a level of acceptable landscape alterations resulting from timber harvesting and other activities; visual quality classes have been defined in B.C. on the basis of the maximum amount of alteration permitted in a given area over a given period of time.

wood quality
A general term encompassing a wide range of physical wood properties and parameters that affect the end use potential and value of wood or wood products; wood quality characteristics can be inherent to particular species, but are also influenced by tree growing conditions, and are also defined by end-use requirements; wood quality parameters include basic density, fibre length, juvenile wood content, fibril angle, compression wood, knot size, frequency and distribution, grain, ring width, and quantity and type of extractives.

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