FRDA REPORT 041

ANALYSIS OF CHANGES IN TIMBER VALUES
DUE TO SILVICULTURE TREATMENTS UNDER THE
CANADA - BRITISH COLUMBIA
FOREST RESOURCE DEVELOPMENT AGREEMENT

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August 1988

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ISSN 0835-0752
Main entry under title:
Analysis of changes in timber values due to silviculture treatments

(FRDA report, ISSN 0835-0752; 041)
Co-published by B.C. Ministry of Forests.
On cover: Canada/B.C. Forest Resource Development Agreement


SD146.B7A52 1988 634.9'O9711 C88-092183-8
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1.0 INTRODUCTION

In October, 1987 the British Columbia Ministry of Forests together with the Canadian Forestry Service commissioned Sterling Wood Group Inc. to undertake this study.

The Canada - British Columbia Forest Resource Development Agreement (FRDA) requires that: "Canada and the Province shall jointly effect an assessment of the programs ... with regard to the stated objectives of A Forest Sector Strategy for Canada, the provincial forest management guidelines and this Agreement." This study forms part of and contributes to the assessment.

Funding for this study has been shared by the two signatories under the Implementation, Communications and Evaluation program within FRDA.
2.0 EXECUTIVE SUMMARY

This analysis was commissioned by the Ministry of Forests and the Canadian Forestry Service under the Canada-British Columbia Forest Resource Development Agreement. It forms part of a wider assessment of the programs funded by the Agreement.

The objective of this study was to determine the changes in value of stems of trees which may result from changes in tree size, particularly diameter, which could be promoted through various silvicultural techniques.

In conducting the analysis the consultant found a surprising lack of empirical data relating stem or log values to physical factors such as log diameter, defect or incidence of knots. Nevertheless, sufficient information was obtained from a variety of sources to provide a useful tool to any practitioner interested in assessing the increases in value that may occur from the increase in tree size prompted by silvicultural treatment.

The methods used to determine the increase in log values are fully described in this report. They are simple and, reflecting the paucity of data, no pretense at sophisticated modelling has been used.

The results are provided in a tabular and graphical form for the interior and coastal regions by major species. It was observed that overall the stem value increases with diameter in the form of a flattened "S"-shaped curve on a graph. The steep portion of the curve depicts a dramatic increase in stem value effected by diameter increase between 15 cm and 25 cm. This reflects a considerable improvement in lumber yield that occurs as a result of the size change.

Traditionally, clear knot-free lumber has been able to command premium prices in the market place. Included with the results are
tables which provide the means for the practitioner to determine increases in value of a stem which will occur given an expected increase in value to a butt log improved by pruning.

The report also discusses trends in values and the conclusions to be drawn indicate that values will increase in real terms and that the practitioner should be optimistic about the future value of both coniferous and deciduous species of trees grown in British Columbia.
3.0 OBJECTIVES AND BACKGROUND

The study objective was to determine the changes in value of stems of trees of the major species in British Columbia resulting from changes in tree size, particularly diameter. The results are to serve as a reference for the determination of commercial value benefits attributable to the achievement of growth through application of silvicultural prescriptions.

Silvicultural prescriptions employed in the practice of intensive forest management are expected to enhance the productivity and increase sustainable yields from the land base. Measurement of these improvements is often done in terms of physical productivity gains that result from a treatment or various intensities of a treatment.

It is more appropriate to evaluate the benefits derived from investment in silvicultural treatments in terms of the value of the forest than by volume alone.

"...investments in intensive forest management should not be evaluated in terms of physical criteria such as maximizing the volume of timber through time from a particular site... The question is whether such investments represent the most efficient allocation of society's scarce resources. Consequently, the appropriate criterion for assessing the desirability of investments in intensive forest management is economic." (Percy, 1986)

Terms of reference required the determination of stem values through a range of appropriate heights and diameters for major B.C. species and for coast and interior regions. In addition to value changes with height and diameter, the value of achieving knot-free clear wood increments to the stem were to be determined. The project did not require the gathering of original data. The approach was to be empirical, using published data, industry and government sources and "best judgement" of the consultants. Stem values would be current, expressed in constant Canadian dollars with 1986 to be used as a base year.
Early in the project it became evident that available base-line data relating to the study are surprisingly scarce. In addition, practical computer techniques, such as growth simulation, are in the process of refinement by some agencies but are not yet available in a form usable for this application.

For the study, all known literature was reviewed, many researchers and practitioners were interviewed and all known accessible data gathered. Sources and persons interviewed are listed in Appendix I.

One of the value changes that the Consultant addressed relates to pruning and the resultant "collar" of clear wood that this silvicultural activity is intended to produce. Several attempts were made to determine the value of clear wood increment to the bole of a tree achieved by pruning but this proved to be elusive because of a lack of data. Specifically, the Consultant was unable to find information showing the volume recovery of clear lumber grades that may be produced from a range of thicknesses of clear collar. In attempting to obtain value increments for this clear collar three potential information sources were examined as follows.

(a) The subject literature. Published study results were found to be insufficient and too inconsistent to establish value increments across the range of diameters addressed by this study.

(b) Computer simulation models. While there is potential for this technique to provide the needed information, no suitable models were available and there was neither time nor funding to develop an appropriate model or to modify an existing one.

(c) Parallel data for old-growth wood. The Consultant possesses data showing the recovery of clear lumber grades to be expected from efficient sawing of old-growth stems. It was hoped that these could be adapted for application to second-
growth stems but, upon examination, it was found that the data reflects old-growth characteristics very different to those of second-growth pruned stems. In the old-growth stems the clear wood component is often asymmetrically contained within the bole which contrasts with the smaller pruned second-growth stems which usually contain a more symmetric and concentric collar of clear wood.

Despite these shortcomings it was possible to calculate the incremental value of the stem if the incremental value of the pruned portion was known (see Tables 5.31 to 5.35). Thus a practitioner who is able to estimate the value of clear wood recovery from butt logs in a pruning scenario specific to his circumstances can use this study to determine the value effect upon whole stems.

Because of the paucity of data, we have made necessary assumptions, extrapolations and interpolations within the report based on our professional judgement and these are noted.

The core of the report consists of sets of tables and graphs, by species, for interior and coastal forest stands. These provide numerical value increments for diameter and height changes which might result from silvicultural treatments. An additional set of tables addresses value increments for the production of clear wood value and "uppers" (i.e. from pruning). These latter tables are provided only for coastal Douglas-fir stands and are based on very limited data because no other exist. Douglas-fir stands are the most likely candidates to receive such treatment in the foreseeable future, but if similar information is sought for other species it too can be developed. The tables and graphs in the report are useful to the practitioner in that once the physical effect of a specific silvicultural treatment has been determined or projected, the value effect of that treatment can also be determined. This in turn allows a financial analysis of cost to benefit or of rate of return.
In addition to, and independent of the provision of numerical data, the consultants were requested to comment on perceived value trends of forest products. This has been done in the report in a subjective manner and the opinions and conclusions are solely those of the consultants.
4.0 METHODOLOGY

4.1 Configuration

The study was split into two separate sections, one for the coast and one for the interior. The distinction between these two regions is broadly recognized administratively by all agencies and especially by the B.C. Ministry of Forests. Stumpage appraisal systems differ distinctly between the coast and interior chiefly because the primary market for forest products is reached at the log level on the coast, while it is at the dimension lumber level in the interior. On the coast there is an active log market wherein some seven million cubic metres are bought and sold annually.¹ This market and the history of prices it provides is a basis from which to value timber on the coast. Moreover, the complexity and diversity of the coastal milling infrastructure inhibits determination of timber values using an end-product system as is used in the interior.

There is no general log market in the interior, hence the primary market for forest products is dimension lumber. Pulp chips also contribute to primary revenues, but market prices are not published, and the revenues are commonly treated as a by-product offset against production costs. For the purpose of this study, the value of the merchantable stem delivered to the mill gate was calculated by deducting conversion costs (net of chip revenue) from the average market value of lumber recovered (see Appendix II, Table 3).

For representative pricing, a 10-year (1978-1987) historical average of all costs and prices was used in this study in order to minimize the influence of economic cycles. All

¹ Source: Valuation Branch, Ministry of Forests and Lands.
dollars are expressed in constant (1986) Canadian currency unless indicated otherwise.

4.2 Determination of Coast Stem Values

Logs bought and sold in the coast log market are priced according to their species and grade. Top-end diameter is one of the chief parameters of the grading system and it is possible to trace the change in log price with changes in diameter criteria. Generally, price varies directly with diameter. There are three values associated with larger diameters which are pertinent here: first, the value of the potential to recover lumber of increasing dimension; second, the value of the potential to extract more aesthetically appealing products, such as clear lumber; and third, there is the value of the effect of increasing diameter on the additional recovery of lumber.

The values determined here are to be applicable to second-growth balsam fir, western red cedar, Douglas-fir, western hemlock and sitka spruce. The log values used to determine stem values were derived from records of log sales comprising mostly old-growth timber. The relevance of using old-growth prices to value second-growth stems is open to question. In B.C.'s coast log market, and within the diameter ranges considered in this study, there is little solid evidence on which to adjust the value of average quality second-growth relative to average quality old-growth. However, a study in the Pacific Northwest United States comparing lumber yields from old- and young-growth Douglas-fir found little if any difference between the two types.1 Hence, the use of unadjusted market log values was

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considered valid and as accurate as is reasonably attainable at this time.

Logs are graded according to the Ministry of Forests alpha nomenclature, A through Y, and the majority of volume falls into a narrow range of grades namely, D, H, I and J (plus shingle grades for western red cedar). By way of example, Douglas-fir top-end diameter criteria (with exceptions for short logs) for these grades are:

- D: \( \geq 76 \text{cm} \).
- H: \( \geq 30 \text{cm} \).
- I: \( \geq 38 \text{cm} \).
- J: \( \geq 10 \text{cm}, \leq 36 \text{cm} \).

H-grade specifications permit smaller and fewer knots than I-grade, hence, although the minimum diameter is lower, it has the potential to yield higher lumber grades and more value. In fact the average diameter of all H-grade is higher than the average for I-grade logs, even though H-grade has a lower permissible minimum diameter. It is generally acknowledged that the price for J-grade and most I-grade reflects construction lumber recovery, while H-grade and D-grade values reflect the expected recovery of a combination of construction and clear lumber. Log length information for the logs contributing price data was unavailable.

Prices tend to rise rapidly through the lower diameters, then plateau through a range until clear recovery expectations are reflected in another strong upward price movement. (See fig. 2, page 13).

The diameter classes applicable to second-growth lie mainly at the lower end of the range (10cm to 30cm) where prices increase rapidly with diameter. This range is represented chiefly by J-grade logs. Unfortunately, this is the only log
grade formally identified in this diameter range\(^1\), and so a price gradient is not available from published prices. However, there is a trade practice in the coast log market that further differentiates J-grade logs into specialized log sorts. On the lower diameter end of this spectrum is the so called "chip-n-saw" sort, and at the upper end is the "large gang" sort. Prices and average diameters for these sorts have been obtained from industry sources. Using this information, it was possible to establish a price gradient through the J-grade range of diameters with the exception of sitka spruce where there is no established market for small log specialty sorts.

Average diameters attributable to average log prices were unavailable from the B.C. Ministry of Forests. Diameter statistics were obtained from the consultants' files and from industry scaling records. Log prices for a range of diameters from 14 cm. to 50 cm., in 1 cm. increments, were interpolated from the data accumulated. These prices were then used to price the log sections (modules) within each stem definition valued. The range of stem sizes valued was from a diameter at breast height (dbh) of 20cm. up to 50cm. in 5cm. increments, and heights of 20m. to 40m. in 5m. increments. The diagram overleaf illustrates the division of the stem into the stump, the merchantable stem (wherin lie the log modules) and the unmerchantable stem top. The graphs on page 13 show the log value base data and the derived module values for coast Douglas-fir.

A computer model devised by the consultant was used to approximate the maximum potential value of the merchantable stem as a sum of the log modules extracted.

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\(^1\) Except X and Y grades which, because they reflect the decadent component, are considered to be insignificant in the context of second-growth.
DIAGRAMATIC REPRESENTATION OF THE DIVISION OF COAST STEMS INTO LOG MODULES

Example for a tree with a height of 35 metres and d.b.h of 25 cm.

\[
TAPER = \frac{dbh}{ht - 1.3} = \frac{25}{35 - 1.3} \\
= 0.742 \text{ cm/m}
\]

Minimum Log Diameter = 10 cm

Merchantable Stem = 21.2 m

DBH = 25 cm

Stump Height = 30 cm

Note: Diagram not to scale
4.3 Determination of Stem Values for the Interior

The determination of values of stems delivered to the mill gate required deduction of conversion costs from, and addition of by-product values to the lumber product value of each diameter class.

An estimate of product yields from each diameter class was needed in order to assign a sales revenue to each. Scarcity of this type of data is well documented (Middleton, 1985). Fortunately, a rigorous analysis of interior Douglas-fir recoveries has been undertaken in British Columbia by the Joint Interior Product Outturn Committee (JIPOC) and the results published by Forintek in 1985. Although similar data were not available for spruce/pine/fir (SPF), the consensus of opinion among experts in industry and at Forintek was that, in second-growth timber, similar lumber recoveries could reasonably be expected from both Douglas-fir and SPF but chip recovery would differ because of variances in specific gravity between species.

It was possible to consult with Forintek personnel who possessed intimate knowledge of the JIPOC study, and who advised the consultants on matters of interpretation and use of the information contained in the published report. The information drawn from this data source was selective and represented the best available data for a contemporary, modern interior sawmill cutting second-growth timber.

Log quality criteria derived from the JIPOC study for the better quality trees approximated second-growth, managed stand quality expectations, i.e.

* No conks.
* No dead or broken tops.
* No fork or crook in lower two-thirds of the tree.
* No scars, rotten branches greater than 10cm. in diameter or frost cracks in lower third.
* No major (greater than 10 degrees) sweep or lean.
* Taper, (dbh / height(cm)) less than 1:48.

Product recoveries for each diameter class in the JIPOC study data were multiplied by lumber prices to determine the gross sales value for each. Prices, expressed in constant 1986 dollars\(^1\), were an average of the ten years 1978-1987 as published by Random Lengths and/or Madisons Lumber Reporter.

A residual value to the mill gate was calculated for each diameter class by deducting conversion costs and adding a pulp chip revenue (see Appendix II, Table 3). A constant conversion cost of $84.00/m\(^3\) and a constant chip return of $50.00/bdu was used. Conversion costs were given careful scrutiny in light of potential variability with log sizes and mill configuration.

Interior sawmill conversion costs used in the determination of log value at the mill gate were found by averaging the costs of a broad selection of interior sawmills over the past 10 years, and converting to 1986 dollars. No adjustments were made to costs per Mfmb to reflect cost changes with diameter because it was found there was a wide divergence of opinion among industry experts whether the cost of converting small logs differs appreciably from that of logs with larger diameters, providing the log is being converted in the manner most efficient for its size. Information was also provided which indicated that small log mills incur average costs that are approximately 10 percent lower per Mfmb than for dimension mills cutting a full range of sizes. However, it has been maintained in a recent publication that milling costs increase by as much as 65

\(^1\) Implicit Gross National Product Price Deflator, Statistics Canada.
percent when log diameter decreases from 30.5 cm to 15.2 cm (Figt and Briggs, 1986).\textsuperscript{1} The conversion cost used is a compromise of actual historical rates and the expected costs that would be incurred by a contemporary modern mill. Recovery rates for pulp chips were derived from J. Dobie, 1978, and the price was set at an average for the base period after consultation with knowledgeable industry sources verified by comparison to the Consultant's confidential records.

The values of logs by diameter class were thus determined and a table of interpolated values by diameter was developed for diameters 10cm. through 50cm. in 1cm. increments. The following graph provides an example.

\textbf{Fig. 4} INTERIOR SPF MODULE VALUES ($/m^3$)

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\textsuperscript{1} In order to deal with this controversy, interior Douglas-fir stem values were subjected to a sensitivity analysis in which stem values were calculated at rates based on an increase between 0\% at 18 cm. top diameter and 50\% for logs with a top diameter of 12.4 cm. Costs for values between 10 cm. and 18 cm. were interpolated from these adjusted values. The resulting stem values are presented in Appendix III.