Sources of Growth Variability in Interior Douglas-fir

Pacific and Yukon Region — Information Report BC-X-328

G.M. Bonnor, R. de Jong and P. Boudewyn

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Abstract

To assess the growth of the uneven-aged stands of Douglas-fir in the Interior Douglas-fir zone of British Columbia, and the factors influencing the growth, data from 92 permanent sample plots were obtained. Volumes ranged from 3 to 496 m^3/ha, with a mean of 94 m^3/ha. Annual growth rates varied from -1.8 to 9.5 m^3/ha, with a mean of 3.3 m^3/ha. Factors included in the analysis were the following: harvesting method (three classes), biogeoclimatic subzone (two classes), time since harvest, and the stand variables of trees per ha, basal area per ha, and quadratic mean diameter. Statistical analyses and visual examinations of scattergrams were applied to plot data compiled according to two utilization limits: trees with a diameter of 9.1 cm and larger, and trees with a diameter of 17.5 cm and larger.

For the 9.1-cm utilization limit data, results of analyses of covariance indicated significant differences among harvesting methods and biogeoclimatic subzones. The data were accordingly divided into four groups with statistically significant differences. A volume growth equation was next derived for each group using the stand variables as independent variables. For two groups (stands harvested using the diameter limit method, and unharvested stands in the dk biogeoclimatic subzone), the number of trees per ha was statistically significant while for a third group (unharvested stands in the xh biogeoclimatic subzone), the number of trees per ha as well as quadratic mean diameter were significant. Another group (stands harvested using the faller's selection method) had no significant independent variables. Considering this result, and since the data base for the faller's selection method included only nine plots with considerable variability in volume growth, this method was excluded from further analysis.

For the 17.5-cm utilization limit data, only three groups had statistically significant differences. One of these groups, stands harvested using the faller's selection method, was subsequently excluded from further analysis for the reasons stated above. For the remaining two groups (stands harvested using the diameter limit method, and unharvested stands), only the number of trees per ha was statistically significant.

While some trends are apparent, they are not well defined and the accuracy of the growth predictions is low; this result is attributed to deficiencies in the data and to natural variability within stands in the interior Douglas-fir zone.

Résumé

Pour évaluer la vitesse d'accroissement de peuplements de Douglas d'âges différents dans la zone intérieure de la Colombie-Britannique et les facteurs pouvant influer sur cet accroissement, des données ont été recueillies à partir de parcelles-échantillons permanentes. Le cubage variait de 3 à 496 m^3/ha, la moyenne étant de 94 m^3/ha. Le taux d'accroissement annuel variait entre -1,8 et 9,5 m^3/ha, la moyenne étant de 3,3 m^3/ha. L'analyse tenait compte des facteurs suivants : méthode de récolte (trois types), sous-zone biogéoclimatique (deux types), temps écoulé depuis la dernière récolte, variables de peuplement par unité d'hectare, surface terrière par unité d'hectare et diamètre de la tige de surface terrière moyenne. Des analyses statistiques et des examens visuels des diagrammes de dispersion ont été appliqués aux données recueillies sur les parcelles récoltées selon deux types de coupe au diamètre minimal : 9,1 cm de diamètre et plus, et 17,5 cm et plus.

Dans le cas des coupes au diamètre minimal de 9,1 cm, les résultats des analyses de la covariance étaient sensiblement différents d'une méthode de récolte á l'autre et d'une sous-zone biogéoclimatique à l'autre. Les données furent donc réparties en quatre groupes de coupe présentant des écarts statistiquement significatifs. Une équation de l'accroissement du cubage a ensuite été formulée pour chacun de ces groupes, les variables de peuplement étant prises comme variables indépendantes. Pour deux de ces groupes (peuplements récoltés selon la méthode de coupe au diamètre minimal et peuplements non récoltés dans la sous-zone biogéoclimatique dk), le nombre d'arbres par unité d'hectare était statistiquement significatif alors que pour un troisième groupe (peuplements non récoltés dans la sous-zone biogéoclimatique xh), le nombre d'arbres par unité d'hectare et le diamètre de la tige de surface terrière moyenne étaient significatifs. Le quatrième groupe (peuplements récoltés selon la méthode de sélection par le bûcheron) ne présentait aucune variable indépendante significative. Compte tenu de ces résultats et étant donné que la base de données concernant les peuplements récoltés selon la méthode de sélection par le bûcheron n'avait été constituée qu'à partir de neuf parcelles caractérisées par des écarts d'accroissement considérables, l'analyse de cette méthode de récolte n'a pas été poursuivie.

Dans le cas des coupes au diamètre minimal de 17,5 cm, seuls trois groupes de données présentaient des écarts statistiquement significatifs. L'analyse de l'un de ces groupes (peuplements récoltés selon la méthode de sélection par le bûcheron) ne fut pas poursuivie pour les mêmes raisons que ci-dessus. L'analyse des deux autres groupes (peuplements récoltés selon la méthode de coupe au diamètre minimal et peuplements non récoltés) révéla que seul le nombre d'arbres par unité d'hectare était statistiquement significatif.

Si certaines tendances ont pu être dégagées de cette analyse, celles-ci ne sont pas nettement définies et le degré d'exactitude des prévisions d'accroissement est relativement bas du fait des déficiences des données et de la variabilité naturelle des peuplements à l'intérieur de la zone de Douglas intérieure.

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- Lawrie Wilson of Lignum Ltd. in Williams Lake
- Ronni Korol of the University of Montana; and
- Frank Hegyi, formerly of the British Columbia Ministry of Forests, Inventory Branch.

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Introduction

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. glauca) is a commercially important species in the British Columbia interior. It has been harvested extensively during the last half century, mostly for lumber. Harvesting methods have ranged from high grading through diameter limit cutting to the current faller's selection method.

The interior Douglas-fir occurs naturally in uneven-aged stands and should be managed accordingly. Better knowledge of the growth and silviculture of the Douglas-fir is necessary to manage these stands properly, and to increase productivity and economic returns. However, the scarcity of permanent sample plots and research installations has resulted in a lack of reliable information.

The purpose of this study is to develop a data base containing Douglas-fir stand growth data, to use this data base to assess the effect on stand growth of differences in harvesting method, time since harvest, site quality and selected stand parameters, and to use the outcome of the assessment to derive a simple stand growth model.

The study is limited in scope to pure Douglas-fir stands in the dry belt of the British Columbia interior. Site quality assessment is limited by data scarcity to the two main biogeoclimatic subzones, IDF (Interior Douglas-fir) dk and xh (Lloyd *et al.* 1989). Stand parameters comprise number of stems, basal area, and quadratic mean diameter. The harvesting methods category comprises the faller's selection method, the diameter limit method (all trees above a specified diameter are harvested), and no harvest. In the faller's selection method, trees may be removed throughout the entire range of diameters. The main objective of the faller's selection method is to develop an uneven-aged stand that can support integrated forest land use (Johnstone 1985).

The Interior Douglas-fir Zone

The main portion of the IDF zone is situated in the Fraser and Thompson Plateaus, extending from Williams Lake in the north to the southern end of the Okanagan Valley (Figure 1). To the east, a narrow band follows the Columbia River. The total area is approximately 4.5 million ha.

The IDF zone has been described by the British Columbia Ministry of Forests (1988). It is the second warmest forest zone of the dry southern interior, occurring in the rain shadow of the Coast, Selkirk and Purcell mountains. Douglas-fir is the dominant tree species. Fires have frequently resulted in even-aged lodgepole pine (*Pinus contorta* Dougl. var. latifolia Engelm.) stands at higher elevations, and ponderosa pine (*P. ponderosa* Laws.) is the common seral tree of the lower elevations. Pinegrass (*Calamagrostis* spp.) and feathermosses (*Hylocomium splendens* (Hedw.) B.S.G.), *Pleurozium schreberi* (Brid.) Mitt.), *Ptilium crista-castrensis* (Hedw.) De Not.) dominate the understory. Soopolallie (*Shepherdia canadensis* (L.) Nutt.) and kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.) are common shrubs. Along its drier limits,

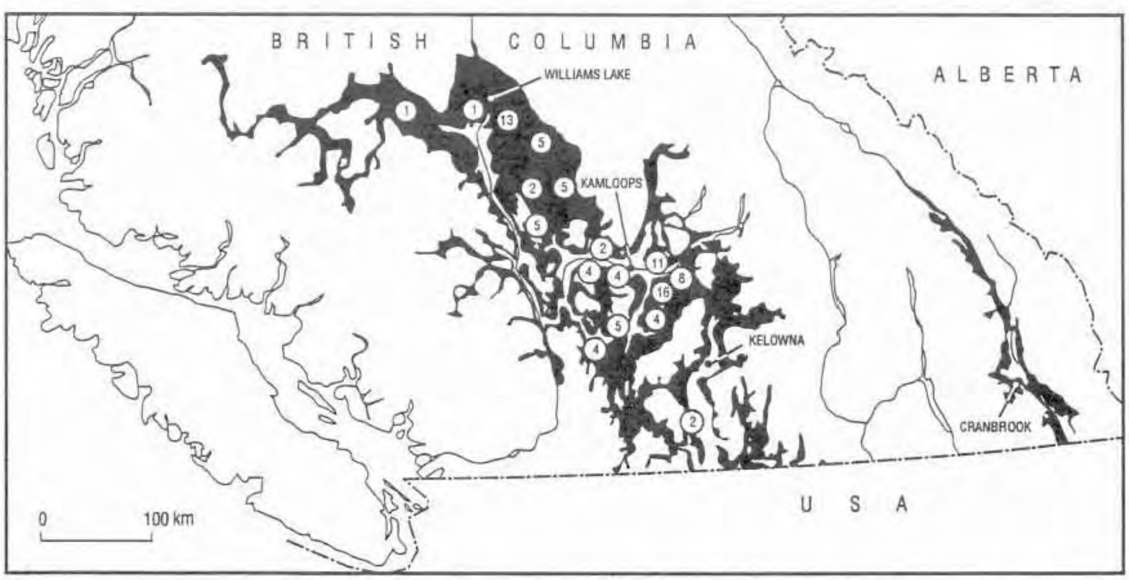

Figure 1: Interior Douglas-fir Zone. (Circled numbers indicate number of plots in that location.)

the zone often becomes savannah-like, supporting bunch grasses including rough fescue (*Festuca scabrella* Torr.) and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith). This zone is important for summer livestock range as well as mule deer and elk habitat. Johnstone (1985) states that the dry-belt has an arid climate with soils that are frequently thin and excessively drained. The forests often have an open stocking and an uneven-aged composition. They are also slower growing and relatively less productive than the remaining stands in the interior. Additional detailed information about the IDF zone is given by Lloyd *et al.* (1989) and Mitchell and Erickson (1983).

The IDF zone is divided into subzones and variants according to temperature, precipitation, and site quality. The most extensive and economically important subzones — and those in which the plots of this study are located — are subzones dk (dry, cool) and xh (xeric, hot). Subzone dk (Table 1) is the largest one, at 2.5 million ha. It occupies the highest elevation and as a result is the coolest and has the shortest frost-free period and the most precipitation. It has two variants: the Thompson Plateau variant in the Kamloops Forest Region, and the Fraser Plateau variant in the Cariboo Forest Region.

Past Work

Data Availability

Johnstone (1985) assessed the problems in estimating the growth and yield of interior dry-belt stands. He stated that reliable growth and yield data for uneven-aged interior fir stands are lacking; the only published information relevant to the dry-belt is Clark's (1952) study of the Douglas-fir-ponderosa pine types in the Okanagan. Johnstone (1985) considered American sources of little help because, as Barber (1980) found, information on silviculture, growth and yield of interior Douglas-fir is scarce. Johnstone listed several sources of data but concluded that most were of doubtful value. Of 105 permanent sample plots established by the British Columbia Ministry of Forests in pure, untreated Douglas-fir stands, most had yet to be remeasured.

Johnstone reviewed growth and yield research installations in the British Columbia interior. (W.D. Johnstone 1987. The present status and proposed plans for managed stand growth and yield research installations in the British Columbia Interior. British Columbia Ministry of Forests, Research Branch, Kalamalka Research Station, Vernon, unpublished report, 13 p.). Of the 12 long-established installations, only one (an espacement study) includes Douglas-fir. Of 11 more recent installations, two include Douglas-fir.

Growth Studies

Along with the scarcity of suitable data — possibly because of it — few growth and yield studies have been undertaken. Johnstone (1985) stated that the lack of knowledge applicable to uneven-aged management in British Columbia is appalling, given the substantial local importance of this method in the interior dry-belt.

In the study by Clark (1952), 153 sample plots were established in four Okanagan locations, three of which had been logged selectively. He used the data — which included increment core measurements — in a stand table projection method to determine stocking and growth. Average gross growth ranged from 2.8 to 3.9 $m^3ha^{-1}yr^{-1}$ on the four sites. Clark found that mortality ranged from 33 to 45% of the gross growth and stated that it could be avoided by logging, e.g., by removing all trees of merchantable size (dbh>28 cm). Such heavy logging would also increase the growth rate of the residual stand. Ten years later, plots from three of the locations were

Table 1. Characteristics of major IDF subzones

Biogeoclimatic subzone	Area (1000 ha)	Average elevation* (m)	Average Precipitation* (mm/yr)	Soil moisture deficit* (months/yr)	Frost free period* (days)	Mean annual temperature* (°C)
dk	2450	1200	425	5	75	4
xh	600	1000	375	5	100	6
Both	3050					

* Based on Lloyd *et al.* (1989), and Mitchell and Erickson (1983)

remeasured and actual growth rates calculated (Clark 1962). The results confirmed the estimates from the stand table projection method; gross growth rates ranged from 2.6 to 3.6 $m^3ha^{-1}yr^{-1}$.

Johnstone (1985) derived stand and stock tables from faller's selection method cutting permit data and a diameter growth equation from Clark's (1952) data, and combined the two in a stand table projection. The resulting gross growth rate of 1.8 $m^3ha^{-1}yr^{-1}$ was considerably smaller than Clark's. The difference may be attributable to differences in site quality and stand structure. However, Johnstone's cutting permit data indicated that the harvests had removed a high proportion of the original stand (55% of the trees, 59% of the basal area) and had substantially altered the stand structure, contrary to the purpose of the faller's selection method.

Pope and Talbot Ltd. (Timber supply analysis report for Tree Farm License #8, management and working plan #7. Unpublished internal report, 1986, 34 p.) used existing inventory data and yield tables to do a timber supply analysis for Tree Farm License #8 in the southern interior. Some of the stands included in the analysis were uneven-aged mixed Douglas-fir and larch.

Smith used data from plots established by Lignum Ltd. of Williams Lake to develop a stand growth projection system. (S.M. Smith. 1987. A stand growth projection system for dry belt Douglas-fir. Unpublished report produced for Lignum Ltd., 29 p.) In the system, ingrowth, stagnation, growth by 5-cm diameter classes, and mortality were derived from probability equations. In one test, the model was used to simulate the effect of spacing. The result indicated that the spaced stand yielded 2.4 times as much timber as the unspaced stand after an 85-year growth projection period.

Data Sets

Data Acquisition

Three data sets were acquired:

1. Data from 63 permanent sample plots established by the British Columbia Ministry of Forests were obtained. All had been remeasured once, hence data from 63 measurement intervals were available. Most permanent sample plots were established in 1977 and remeasured in 1987; a few came from research installations. A subset of 12 plots was established in cooperation with Balco Ltd. (now Tolco Ltd.) near Kamloops. Most of the plots were harvested using the diameter limit method which prevailed in the IDF zone prior to 1977. Some of the plots were harvested as early as 1956.

2. In 1984, Lignum Ltd. of Williams Lake evaluated results of a 1978 thinning in three stands. They established a permanent sample plot in the thinned part and another in the control part of each stand. Increment cores were extracted and trees outside the plots were felled for stem analysis, and the resulting data were used to derive stem diameters back to 1972. These were in turn used to estimate plot volumes and growth for the two 6-year periods 1972-78 and 1978-84. Since the control stands previously had been logged using the diameter limit method, they were classified as such. A report on the establishment of the plots and analysis of the data was produced by (D.W. Ormerod. 1986. Analysis of Lignum Ltd. interior Douglas-fir spacing. Unpublished report produced for the British Columbia Ministry of Forests Research Branch, 4 p.).

In 1980, an old-growth stand was harvested using the faller's selection method and two permanent sample plots (harvested and unharvested) were established. These were remeasured in 1987. Measurements and compilations were similar to those of the preceding plots. In total, five plots and eight measurement intervals were available.

3. R.L. Korol of the University of Montana established 24 permanent sample plots in 1986 in the Kamloops area. In 1987, increment cores were extracted from all trees within the plots, and trees in the surrounding stands were felled for stem analyses. From these, tree diameters from the past 25 years were measured at 5-year intervals. As for the Lignum plots, volumes and growth data were also compiled. However, where plots had been harvested, compilations were limited to the years after harvest. A total of 100 measurement intervals were available. Most Korol plots are unharvested.

In some cases, where clusters of small plots had been established, they were combined to form one permanent sample plot. Size of the permanent sample plots ranged from 500 to 1500 m^2.

Plot locations are shown in Figure 1. While the central portion of the IDF zone is well covered, few are near the limits and none is in the Columbia River Valley. Of the 92 plots, 65 (and 119 measurement intervals) are located in subzone dk, while 27 (and 54 measurement intervals) are in subzone xh.

Data evaluation and compilation

First, the classification of each plot was checked. Particular attention was paid to the harvesting method and date. Plots were visually inspected, local foresters were interviewed, and old cutting permits were examined.

The biogeoclimatic subzones used to classify the plots by site were next obtained from maps compiled by the British Columbia Ministry of Forests. Conversion from an old to a new classification system was necessary.

One concern was that the plots might differ in their characteristics due to the methodology used to obtain the data, i.e., that they might differ by ownership. A scattergram of volume growth over volume by ownership categories was produced. It revealed no trends or patterns; hence no significant differences due to methodology were assumed to exist.

The extent to which the plots were uneven-aged was also evaluated: graphs of number of stems per ha by diameter class were produced, q-values (see e.g., Leak 1963) were calculated, and individual tree ages were obtained where possible. No plots were deleted for being even-aged.

The Lignum and Korol data sets, being constructed from increment cores and stem analysis data, did not have any data on ingrowth and mortality. Mortality estimates were obtained by constructing, from the remeasured Ministry of Forests permanent sample plots, equations giving the probability of mortality by 5-cm diameter classes for specified periods. These equations were used to add "mortality trees" to the initial Lignum and Korol data sets. No corrections for ingrowth were attempted since any changes in volume and increment would be minimal.

For the Lignum data, another problem was that past diameters were derived only for selected crop trees in the main plots. However, subplot data included past diameters of all trees. The growth rates derived from these were used to obtain past diameters of noncrop trees in the main plots. Since growth rates might differ with diameter, this step was done by diameter classes.

The minimum measured dbh varied with the data sets, the highest one being 9.1 cm. To put the data on a common basis, trees with a diameter less than 9.1 cm were discarded.

The individual tree data were next used to compile tree and plot characteristics, as follows.

1. Procedures devised by the British Columbia Ministry of Forests (J. Braz, Inventory Branch, British Columbia Ministry of Forests, personal communication) were used to develop a height-diameter equation: plots were stratified by biogeoclimatic zone, growth type and site class, and a regression equation (modified Weibull function) was fitted to each stratum data set. For each tree lacking a measured height, a height was derived from the equation.

2. Tree volume equations used by the British Columbia Ministry of Forests (1976 whole stem cubic metre volume equations) were used to calculate individual tree volumes.

3. Tree volumes, number of trees, and basal areas were summarized within each plot and converted to per-hectare values for two utilization limits: all trees with a diameter 9.1 cm or larger, and all trees with a diameter of 17.5 cm or larger.

4. Growth data were obtained by subtracting volumes measured on successive dates. To facilitate comparisons, a 5-year growth interval was adopted as standard. This required a conversion from other intervals for some plots. The conversion was done by calculating the average annual growth rate which was then multiplied by five.

Figure 2 provides a visual check of the plot data and an opportunity to spot outliers. While most plots cluster around a volume growth of 3 $m^3ha^{-1}yr^{-1}$ and a volume of 100 m^3ha^{-1}, a few plots deviate significantly. The two (Balco) plots showing growth rates approaching 10 $m^3ha^{-1}yr^{-1}$ are located on superior sites and have been harvested. The one (Lignum) plot with a volume approaching 496 m^3ha^{-1} is located in an old-growth forest which has never been harvested. One plot shows a negative growth rate because a large tree died between measurements.

Plot characteristics are summarized in Tables 2 and 3 by harvesting method for the two utilization limits. The most significant features are the high averages and narrow ranges of basal area, quadratic mean diameter and volume in plots harvested by the faller's selection method. The small ranges are likely related to the small sample size. The unharvested plots have, as expected, more stems per ha than the harvested plots. The large volume range of the unharvested plots is caused by one plot, the Lignum old-growth plot, having a volume of 496 m^3ha^{-1}. Apart from that plot, the volume range is similar to those of the other two harvesting methods.

The penultimate step was the creation of a data base containing a standard set of data for each plot. The data base was used to compile a plot summary data set (Appendix).

Results

A primary tool in analysing the data was the General Linear Model Procedure (PROC GLM) (SAS Institute Inc. 1985). It will handle discrete classificatory variables as well as continuous independent variables. Considering the incomplete cross-classification of the data set, orthogonal contrasts were used in GLM to separate cell means. In addition to GLM, regression analysis was carried out using procedures STEPWISE and RSQUARE for exploratory analysis, and procedure REG for confirmatory analysis, followed by plotting (using procedure GPLOT) with visual inspection of the plots. All statistically significant differences were at the 99% level (p=0.01).

Lower Utilization Limit

The first set of statistical analysis were analyses of covariance, in which the main and interaction effects of harvesting method and biogeoclimatic sub-zone were evaluated using orthogonal contrasts.

Initial volume (at the start of the growth interval) was used as an independent variable in these analyses, yielding volume growth means adjusted to correspond to the overall mean for initial volume.

Significant differences in volume growth were detected between plots harvested using the faller's selection method and plots harvested with the diameter limit method, and between plots harvested with the faller's selection method and unharvested plots; these differences were present regardless of the biogeoclimatic subzone of the plots. Significant differences were also found between unharvested plots of subzones dk and xh. Finally, significant differences between unharvested plots and plots harvested with the diameter limit method were present for subzone dk, but not for subzone xh.

These results may be interpreted by reference to the mean growth values of Table 4: the volume growth in the plots harvested with the faller's selection method, at 5.0 and 4.1 $m^3ha^{-1}yr^{-1}$ in subzones dk and xh, respectively, is higher than in the other plots while the volume growth in the unharvested plots of subzone xh (2.6 $m^3ha^{-1}yr^{-1}$) is lower.

In a subsequent analysis with trees per ha, basal area per ha and quadratic mean diameter as independent variables, regression coefficients were found to differ among plots with different harvesting methods but not among plots in different biogeoclimatic subzones, nor among interaction effects. Therefore, plots with the three harvesting methods were grouped separately because of mean and regression differences, and subzones were grouped separately for unharvested plots because of mean differences, resulting in the following four groups:

- All plots harvested with the faller's selection method;
- All plots harvested with the diameter limit method;
- Unharvested plots in the dk subzone; and
- Unharvested plots in the xh subzone.

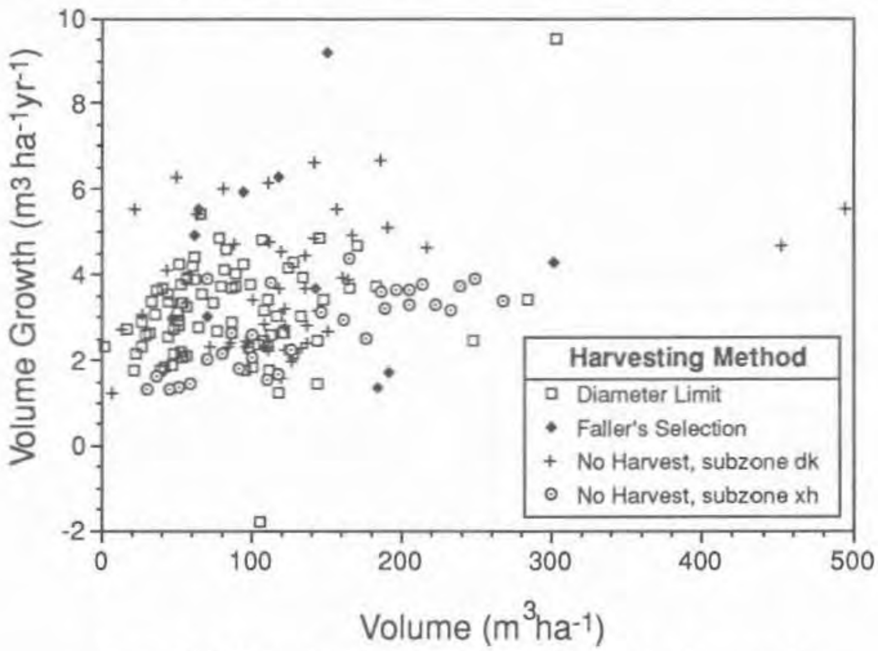

Figure 2. Relationship between volume growth and volume per ha

A second analysis of covariance which included the above groups as well as the previous independent variables (time since harvest, trees per ha, basal area per ha, and quadratic mean diameter) was run. The analysis showed that the time since harvest had no significant effect on volume growth while the remaining three variables did.

Plotting volume growth against time since harvest, trees per ha, basal area per ha and quadratic mean diameter by groups (Figures 3, 4, 5 and 6) illustrates these relationships. The relationship between volume growth and time since harvest (Figure 3) is constant for plots harvested with the faller's selection and diameter limit methods, confirming the lack of significant correlation; time since harvest was therefore deleted from subsequent analyses. Some positive trends are apparent in Figures 4 and 5.

To confirm these assessments and convert them into usable equations, a set of forward elimination, stepwise regressions were run. For each group, up to two variables (of trees per ha, basal area per ha, and quadratic mean diameter) were selected for inclusion in the equation. The results are as follows.

1) For plots harvested with the faller's selection method, no independent variable was significant, i.e. the growth rate was not significantly correlated with number of trees per ha, basal area per ha, or quadratic mean diameter. This result is contrary to normal growth patterns and, while it may be explained by the small sample size (nine plots), small range of the independent variables, and high variability in volume growth (Figures 3-6), the data must be considered unreliable. Accordingly, plots harvested using the faller's selection method were excluded from further analyses.

2) For plots harvested with the diameter limit method and for unharvested plots in the dk subzone, trees per ha was significant, while for unharvested plots in subzone xh the significant variables were

Table 2. Plot characteristics* for a 9.1-cm utilization limit, by harvesting method.

Harvesting method	Stem frequency (no./ha)		Basal area (m^2/ha)		Quadratic mean diameter (cm)		Volume (m^3/ha)		No. of Plots	Measurement Intervals
	ave.	range	ave.	range	ave.	range	ave.	range		
Diameter limit	443	67 - 1367	14	1 - 45	20	11 - 46	84	3 - 303	66	84
Faller's selection	532	383 - 800	19	9 - 40	21	15 - 32	131	48 - 303	9	11
Unharvested	742	200 - 1650	19	2 - 60	18	11 - 30	114	8 - 496	17	78
All	507	67 - 1650	15	1 - 60	20	11 - 46	94	3 - 496	92	173

* At initial measurement.

Table 3. Plot characteristics* for a 17.5-cm utilization limit, by harvesting method.

Harvesting method	Stem frequency (no./ha)		Basal area (m^2/ha)		Quadratic mean diameter (cm)		Volume (m^3/ha)		No. of Plots	Measurement Intervals
	ave.	range	ave.	range	ave.	range	ave.	range		
Diameter limit	165	1 - 650	10	0 - 39	27	0 - 47	69	0 - 276	66	84
Faller's selection	195	50 - 300	15	3 - 37	31	21 - 42	111	21 - 292	9	11
Unharvested	181	1 - 413	12	0 - 54	24	0 - 42	83	0 - 431	17	78
All	171	1 - 650	11	0 - 54	27	0 - 47	76	0 - 431	92	173

* At initial measurement.

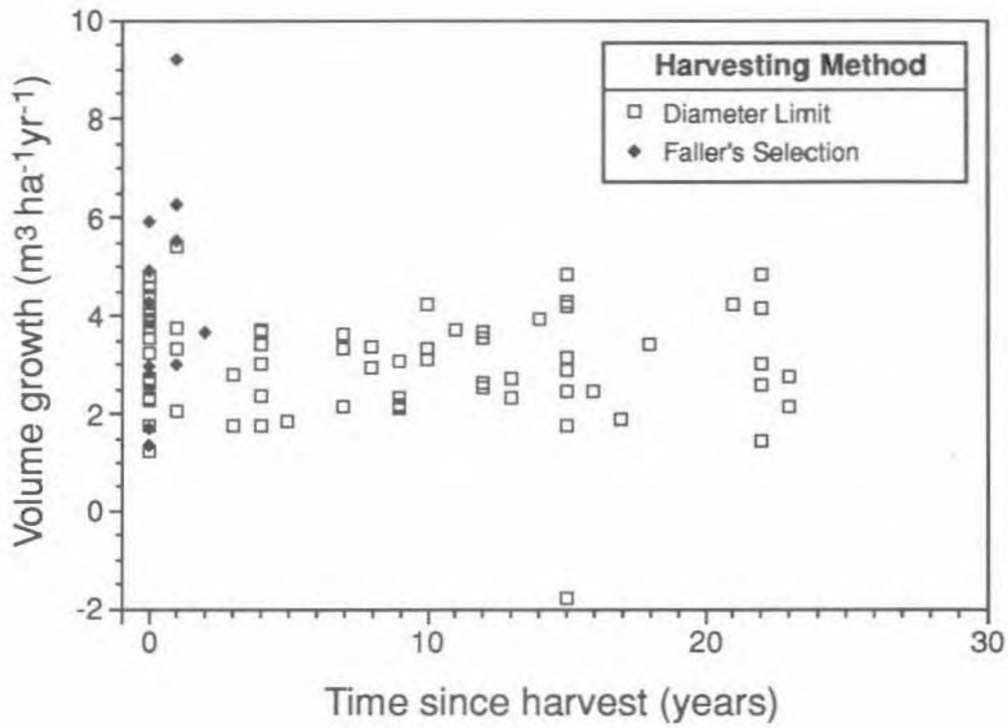

Figure 3. Relationship between volume growth and time since harvest

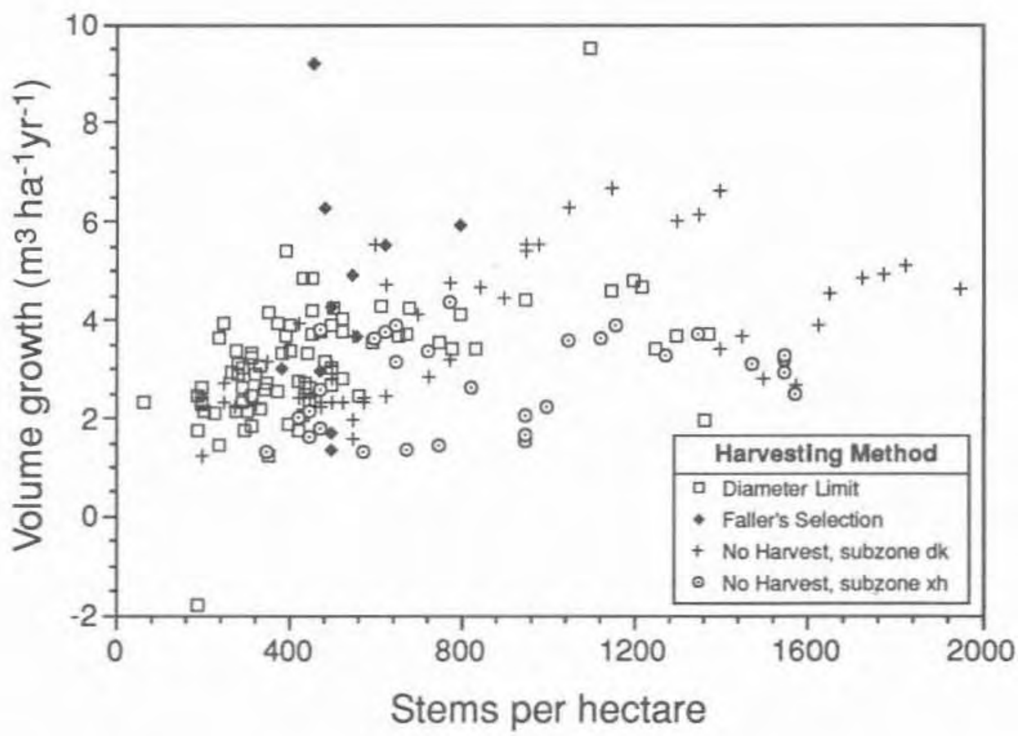

Figure 4. Relationship between volume growth and stems per ha

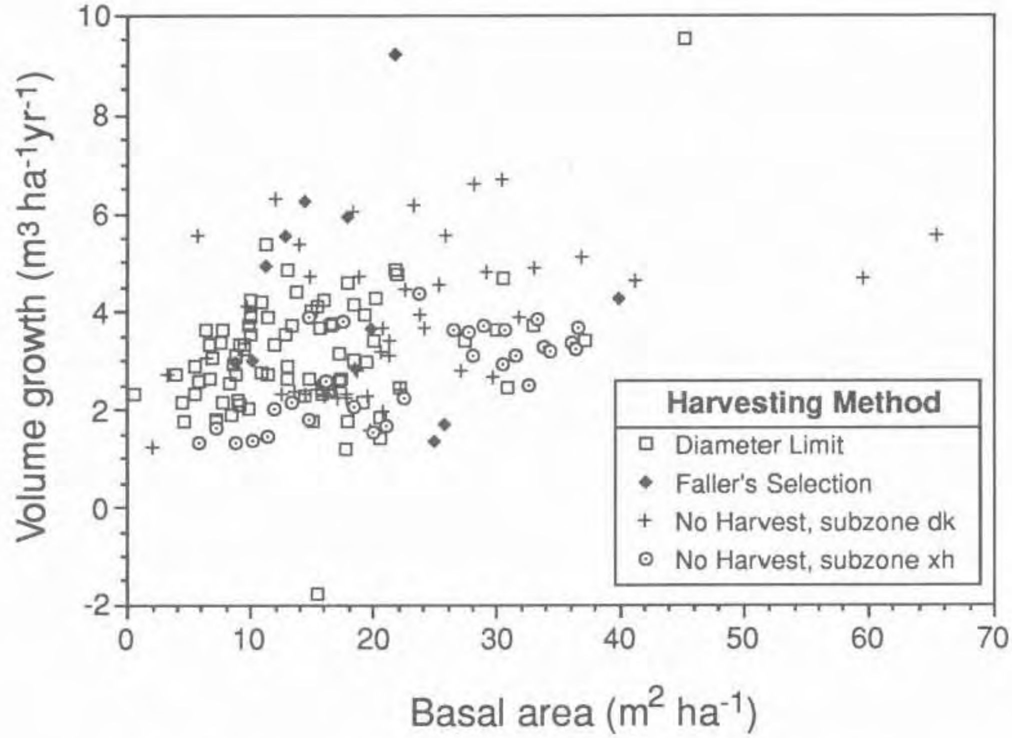

Figure 5. Relationship between volume growth and basal area per ha

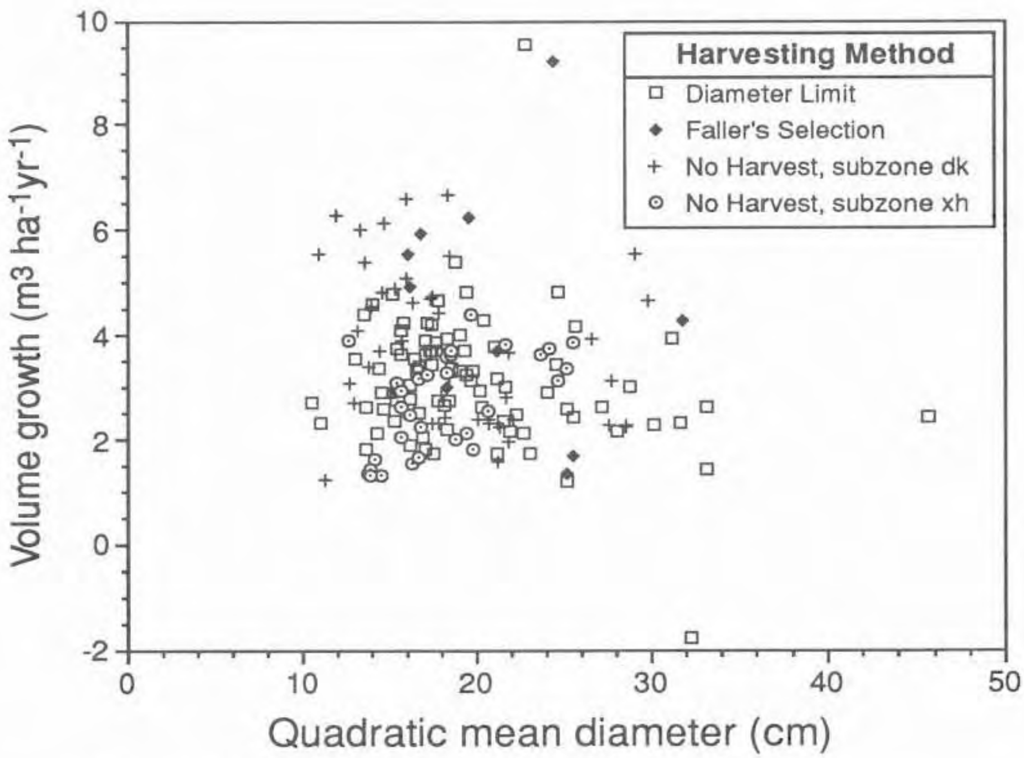

Figure 6. Relationship between volume growth and quadratic mean diameter

Table 4. Stand growth ($m^3ha^{-1}yr^{-1}$) by biogeoclimatic subzone and harvesting method*

Biogeoclimatic Subzone	Diameter limit	Faller's selection	Unharvested	All
dk	3.2	5.0	3.5	3.4
xh	3.6	4.1	2.6	3.2
Both	3.3	4.4	3.2	3.3

* Trees >9.1 cm in dbh

Table 5. Volume growth equations* for a 9.1-cm utilization limit

Group	Equation	Sample Size	R^2	Standard error of estimate ($m^3ha^{-1}yr^{-1}$)	Standard error of estimate (% of mean)
Diameter limit harvesting method	$VGR=1.35+0.00550TPH-0.00000286TPH^2$	81	0.28	0.8	25
Unharvested stands in subzone dk	$VGR=-0.314+0.00812TPH-0.00000291TPH^2$	38	0.60	1.0	28
Unharvested stands in subzone xh	$VGR=-1.90+0.00152TPH+0.183QMD$	24	0.47	0.7	24

* VGR = volume growth ($m^3ha^{-1}yr^{-1}$)
TPH = trees per ha
QMD = quadratic mean diameter (cm)

Table 6. Volume growth ($m^3ha^{-1}yr^{-1}$) from equations presented in Table 5*

Group	Trees per hectare 100	300	500	700	900	1100	1300	1500	Quadratic mean diameter
Diameter limit harvesting method	1.9	2.7	3.4	3.8	4.0	3.9	3.6		-
Unharvested stands in subzone dk		1.9	3.0	3.9	4.6	5.1	5.3	5.3	-
Unharvested stands in subzone xh			1.6	1.9	2.2	2.5	2.8	3.1	15
			2.5	2.8	3.1				20
			3.4	3.7					25

* Trees >9.1 cm in dbh.

Table 7. Volume growth equations* for a 17.5-cm utilization limit

Group	Equation	Sample Size	R^2	Standard error of estimate ($m^3ha^{-1}yr^{-1}$)	Standard error of estimate (% of mean)
Diameter limit harvesting method	VGR = 0.90 + 0.00913TPH	84	0.40	1.49	60
Unharvested stands	VGR = 1.76 + 0.00463TPH	64	0.14	2.36	80

* VGR = volume growth ($m^3ha^{-1}yr^{-1}$)
TPH = trees per ha
QMD = quadratic mean diameter (cm)

trees per ha and quadratic mean diameter. The equations for these three groups (Table 5) were used to derive growth rate tables for different values of trees per ha and quadratic mean diameter (Table 6).

Higher Utilization Limit
The statistical analyses done for the plot data compiled to the smaller utilization limit (9.1 cm) were repeated for the larger limit (17.5 cm). The results were similar with two exceptions. First, the difference between the two subzones of the unharvested plots was no longer statistically significant; hence, equations for only two groups were constructed: plots harvested with the diameter limit method, and unharvested plots. Secondly, the quadratic mean diameter was no longer a significant independent variable in the equations. The new set of volume growth equations (Table 7) was used to derive growth rate tables for different values of trees per ha (Table 8).

Discussion and Conclusions

The basic data set suffers from a number of deficiencies: incomplete coverage of parameter combinations and geographic locations, different measurement periods and procedures, and variability in harvesting intensity and quality. As an example, the stem analysis methods used to obtain the Korol and Lignum data cannot provide in growth and mortality data; such data are available only from the plots established by the British Columbia Ministry of Forests.

Fortunately, ingrowth is of little consequence in estimating volume growth and mortality is minor (less than 1%), so this deficiency does not disqualify the Korol and Lignum permanent sample plots from use. The deficiencies create considerable "noise" in the data which makes it difficult to determine relationships and trends and decreases the accuracy of the estimates.

These deficiencies in the data are compounded by a natural variability within IDF stands. For example, some uneven-aged stands include pockets of dense, small, seemingly even-aged trees. Stem diameter frequency distributions and q-values fitted to them support the apparent even-aged nature of the pockets. However, frequency distributions by age look no different for them than for the remainder of the stand, indicating that they are indeed uneven-aged. Another characteristic of these plots is the relatively rapid increase in trees per ha with time, a result of many small trees moving into the measured size class (9.1 cm and larger).

Site quality is known to have considerable influence on tree and stand growth, yet the results emerging from this study are not clear.

Analyses of the unharvested plots indicate that Douglas-fir grows better in the dk subzone than in the xh subzone. However, this indication is not supported by the results for the harvested stands.

One possible reason is that the biogeoclimatic subzones are too broad to quantify differences in volume growth. The possibility that tussock moth

Table 8. Volume growth ($m^3ha^{-1}yr^{-1}$) from equations presented in Table 7*

Group	Trees per hectare 100	300	500
Diameter limit harvesting method	1.8	2.7	5.4
Unharvested stands	2.2	3.2	-

* Trees >17.5 cm in dbh.

(*Orgyia pseudotsugata* (McD.)) infestations may have reduced the growth rate of plots in the xh subzone was also investigated; no evidence of infestation or of growth loss was apparent.

The volume growth equations (Tables 5 and 7) all include trees per ha as an independent variable because the statistical analyses indicated that it had a higher correlation with volume growth than the other two variables, basal area per ha and quadratic mean diameter. However, the analyses also showed that the differences were slight; the other two variables were almost equally good. The variability of the data is such that the true relationship can only be approximated.

The relationships between volume growth, trees per ha, and quadratic mean diameter (Tables 5,6,7 and 8) appear reasonable: as trees per ha and quadratic mean diameter increase, so does volume growth up to a point where the stand becomes too dense, then it levels off or decreases. Within the range of the sample plot data (Tables 6 and 8) the predicted growth values also appear reasonable, ranging from 1.6 to 5.4 $m^3ha^{-1}yr^{-1}$.

The precision of the estimates is indicated by the standard errors of estimates in Tables 5 and 7. For a 9.1-cm utilization limit data (Table 5), the standard errors are 24-28% while for a 17.5-cm limit, the errors are much higher at 60-80%. A standard error of 25% indicates that, two times out of three, the true value will be within 25% of the estimated mean. For example, if a stand with 500 trees per ha is harvested using the diameter limit method, the true growth rate (at a 9.1-cm utilization limit) will likely be in the 2.6-4.2 $m^3ha^{-1}yr^{-1}$ range.

The growth rates obtained here are similar to those obtained previously. Clark (1952) found the growth rates to range from 2.8 to 3.9 $m^3ha^{-1}yr^{-1}$, while Johnstone (1985) derived a rate of 1.8 $m^3ha^{-1}yr^{-1}$. However, mean annual increment values used by the British Columbia Ministry of Forests in timber supply analysis reports currently range from 3.7 to 4.4 $m^3ha^{-1}yr^{-1}$ for good sites. For medium sites, the range is 2.0 to 2.7 $m^3ha^{-1}yr^{-1}$.

The equations of Tables 5 and 7 comprise a simple stand based growth model. To use it requires the following input data:

1) a specified utilization limit (9.1 or 17.5 cm);
2) harvesting method (diameter limit harvesting or no harvest) and, for unharvested stands with a utilization limit of 9.1 cm, biogeoclimatic subzone (dk or xh). This information can be obtained from harvesting records and maps;
3) number of trees per ha and, for unharvested stands in subzone xh with a utilization limit of 9.1 cm, quadratic mean diameter. These data are available from provincial forest inventories but only for stands that have been field sampled. However, by aggregating similar stands into groups that include field plot data, approximate growth estimates may be obtained for stands not sampled in the field.

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Appendix

Plot summary data set

Plot no.	UTM reference Zone	Easting	Northing	Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3ha^{-1}yr^{-1}$)
1	10	312000	5462000	BCM	DK	DL	7708	10	287.1	8.8	19.8	50.9	9	3.13
2	10	302000	5476000	BCM	DK	DL	7708	14	376.2	10.1	18.4	58.0	9	3.94
3	10	646000	5545500	BAL	XH	DL	8108	18	780.0	37.2	24.6	284.9	5	3.43
4	10	646000	5545500	BAL	XH	FS	8108	2	560.0	19.8	21.2	144.0	5	3.70
5	10	647200	5533500	BAL	XH	NO	8206	.	1160.0	14.8	12.7	71.5	5	3.91
6	10	647200	5533500	BAL	XH	FS	8205	1	483.3	14.5	19.6	118.1	5	6.28
7	10	689500	5576980	KOR	XH	NO	6209	.	825.0	16.2	15.8	87.6	5	2.62
7	10	689500	5576980	KOR	XH	NO	6709	.	950.0	18.5	15.7	100.7	5	2.07
7	10	689500	5576980	KOR	XH	NO	7209	.	950.0	20.0	16.4	111.0	5	1.54
7	10	689500	5576980	KOR	XH	NO	7709	.	950.0	21.1	16.8	118.7	5	1.68
7	10	689500	5576980	KOR	XH	NO	8209	.	1000.0	22.4	16.9	127.1	5	2.25
8	10	689500	5576980	KOR	XH	NO	6209	.	600.0	26.5	23.7	197.3	5	3.64
8	10	689500	5576980	KOR	XH	NO	6709	.	625.0	29.0	24.3	215.5	5	3.75
8	10	689500	5576980	KOR	XH	NO	7209	.	650.0	31.5	24.8	234.3	5	3.14
8	10	689500	5576980	KOR	XH	NO	7709	.	650.0	33.4	25.6	250.0	5	3.88
8	10	689500	5576980	KOR	XH	NO	8209	.	725.0	36.1	25.2	269.3	5	3.38
9	10	692350	5575900	KOR	DK	DL	7209	4	1250.0	27.3	16.7	148.6	5	3.41
9	10	692350	5575900	KOR	DK	DL	7709	4	1300.0	30.0	17.1	165.6	5	3.66
9	10	692350	5575900	KOR	DK	DL	8209	4	1375.0	33.0	17.5	183.9	5	3.72
10	10	692350	5575900	KOR	DK	DL	7209	4	425.0	15.2	21.3	96.5	5	1.76
10	10	692350	5575900	KOR	DK	DL	7709	4	450.0	16.6	21.6	105.3	5	2.36
10	10	692350	5575900	KOR	DK	DL	8209	4	500.0	18.5	21.7	117.1	5	3.04
11	10	669850	5563150	BCM	DK	DL	7708	22	346.5	17.3	25.2	113.2	10	2.60
12	10	669800	5563300	BCM	DK	DL	7708	22	297.0	19.5	28.9	134.0	10	3.01
13	10	677000	5562350	BCM	DK	DL	7708	22	237.6	20.6	33.2	144.3	10	1.44
14	10	656600	5574600	BCM	DK	DL	7708	22	455.4	21.8	24.7	146.5	10	4.85
15	10	657100	5573900	BCM	DK	DL	7708	22	356.4	18.4	25.7	124.8	10	4.18
16	10	633150	5620000	BCM	XH	DL	7706	5	316.8	7.2	17.1	42.4	11	1.83
17	10	636000	5619850	BCM	XH	DL	7706	3	188.1	4.6	17.6	22.4	11	1.75
18	10	636000	5619600	BCM	XH	DL	7706	3	524.8	10.9	16.3	52.3	11	2.79

Appendix continued

Plot no.	UTM reference Zone	Easting	Northing	Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3 ha^{-1} yr^{-1}$)
19	10	643725	5619400	BCM	XH	DL	7706	7	277.2	4.5	14.4	24.1	11	2.15
20	10	700250	5599250	KOR	XH	NO	6209	.	775.0	23.7	19.7	165.6	5	4.40
20	10	700250	5599250	KOR	XH	NO	6709	.	1050.0	27.8	18.4	187.6	5	3.61
20	10	700250	5599250	KOR	XH	NO	7209	.	1125.0	30.7	18.6	205.6	5	3.65
20	10	700250	5599250	KOR	XH	NO	7709	.	1275.0	33.9	18.4	223.9	5	3.31
20	10	700250	5599250	KOR	XH	NO	8209	.	1350.0	36.6	18.6	240.4	5	3.71
21	10	700250	5599250	KOR	XH	NO	6209	.	425.0	12.0	18.9	71.3	5	2.02
21	10	700250	5599250	KOR	XH	NO	6709	.	450.0	13.4	19.5	81.4	5	2.15
21	10	700250	5599250	KOR	XH	NO	7209	.	475.0	14.8	19.9	92.2	5	1.82
21	10	700250	5599250	KOR	XH	NO	7709	.	475.0	16.0	20.7	101.3	5	2.57
21	10	700250	5599250	KOR	XH	NO	8209	.	475.0	17.5	21.7	114.1	5	3.83
22	10	702550	5604400	KOR	XH	NO	6209	.	1475.0	28.0	15.5	147.5	5	3.11
22	10	702550	5604400	KOR	XH	NO	6709	.	1550.0	30.5	15.8	163.0	5	2.94
22	10	702550	5604400	KOR	XH	NO	7209	.	1575.0	32.6	16.2	177.7	5	2.50
22	10	702550	5604400	KOR	XH	NO	7709	.	1550.0	34.3	16.8	190.2	5	3.19
22	10	702550	5604400	KOR	XH	NO	8209	.	1550.0	36.5	17.3	206.2	5	3.27
23	10	702550	5604400	KOR	XH	FS	7709	0	500.0	25.0	25.2	185.5	5	1.36
23	10	702550	5604400	KOR	XH	FS	8209	0	500.0	25.8	25.6	192.3	5	1.71
24	10	698750	5599950	KOR	DK	NO	6209	.	200.0	2.1	11.4	8.3	5	1.26
24	10	698750	5599950	KOR	DK	NO	6709	.	250.0	3.3	13.0	14.6	5	2.72
24	10	698750	5599950	KOR	DK	NO	7209	.	500.0	6.5	12.8	28.2	5	3.09
24	10	698750	5599950	KOR	DK	NO	7709	.	700.0	9.7	13.3	43.7	5	4.12
24	10	698750	5599950	KOR	DK	NO	8209	.	950.0	14.0	13.7	64.3	5	5.41
25	10	698750	5599950	KOR	DK	NO	6209	.	475.0	16.1	20.8	97.1	5	2.34
25	10	698750	5599950	KOR	DK	NO	6709	.	500.0	17.9	21.3	108.8	5	2.33
25	10	698750	5599950	KOR	DK	NO	7209	.	550.0	19.7	21.3	120.5	5	1.59
25	10	698750	5599950	KOR	DK	NO	7709	.	550.0	20.8	21.9	128.4	5	1.98
25	10	698750	5599950	KOR	DK	NO	8209	.	575.0	22.3	22.2	138.3	5	2.42
26	10	683200	5605100	BAL	DK	DL	8201	.	833.3	20.0	17.5	111.7	5	3.44
27	10	683200	5605100	BAL	DK	FS	8201	1	625.0	12.8	16.1	65.4	5	5.57
28	10	688500	5599250	KOR	XH	NO	6209	.	350.0	5.9	14.6	31.1	5	1.33
28	10	688500	5599250	KOR	XH	NO	6709	.	450.0	7.2	14.3	37.8	5	1.62

Appendix continued

Plot no.	UTM reference Zone	Easting	Northing	Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3ha^{-1}yr^{-1}$)
28	10	688500	5599250	KOR	XH	NO	7209	.	575.0	8.9	14.0	45.9	5	1.34
28	10	688500	5599250	KOR	XH	NO	7709	.	675.0	10.2	13.9	52.5	5	1.36
28	10	688500	5599250	KOR	XH	NO	8209	.	750.0	11.5	14.0	59.3	5	1.45
29	10	688500	5599250	KOR	XH	FS	7709	0	475.0	8.9	15.4	47.8	5	2.98
29	10	688500	5599250	KOR	XH	FS	8209	0	550.0	11.3	16.2	62.7	5	4.95
30	10	685750	5600950	KOR	DK	NO	6209	.	1400.0	21.3	13.9	102.1	5	3.41
30	10	685750	5600950	KOR	DK	NO	6709	.	1450.0	24.2	14.6	119.1	5	3.70
30	10	685750	5600950	KOR	DK	NO	7209	.	1500.0	27.2	15.2	137.6	5	2.82
30	10	685750	5600950	KOR	DK	NO	7709	.	1575.0	29.7	15.5	151.7	5	2.67
30	10	685750	5600950	KOR	DK	NO	8209	.	1625.0	31.9	15.8	165.1	5	3.90
31	10	685750	5600950	KOR	DK	DL	7709	0	500.0	13.0	18.2	77.2	5	2.66
31	10	685750	5600950	KOR	DK	DL	8209	0	525.0	15.0	19.1	90.5	5	4.02
32	10	684100	5595200	BAL	DK	DL	8009	.	1220.0	30.6	17.9	171.2	5	4.69
33	10	684100	5595200	BAL	DK	FS	8009	0	800.0	17.9	16.9	94.5	5	5.97
34	10	684200	5588450	KOR	DK	NO	6209	.	1650.0	25.4	14.0	120.5	5	4.56
34	10	684200	5588450	KOR	DK	NO	6709	.	1725.0	29.2	14.7	143.3	5	4.84
34	10	684200	5588450	KOR	DK	NO	7209	.	1775.0	33.1	15.4	167.5	5	4.93
34	10	684200	5588450	KOR	DK	NO	7709	.	1825.0	37.0	16.1	192.1	5	5.12
34	10	684200	5588450	KOR	DK	NO	8209	.	1950.0	41.3	16.4	217.7	5	4.63
35	10	684200	5588450	KOR	DK	DL	7709	0	450.0	14.7	20.4	86.8	5	2.64
35	10	684200	5588450	KOR	DK	DL	8209	0	475.0	16.7	21.1	100.0	5	3.78
36	10	665100	5615250	BCM	XH	DL	7706	1	435.6	9.9	17.0	55.5	11	2.05
37	10	665100	5615050	BCM	XH	DL	7706	1	445.5	9.6	16.6	54.3	11	3.34
38	10	668500	5607200	BAL	XH	DL	8204	.	1366.7	20.5	13.8	101.5	5	1.84
39	10	668500	5607200	BAL	XH	FS	8204	1	383.3	10.2	18.4	71.0	5	3.04
40	11	311200	5591450	BCM	DK	DL	7708	15	564.4	22.2	22.4	144.6	10	2.48
41	11	311200	5599180	BCM	DK	DL	7708	15	485.1	17.2	21.2	108.3	10	3.16
42	11	305300	5616950	KOR	DK	NO	6209	.	625.0	14.9	17.4	88.9	5	4.73
42	11	305300	5616950	KOR	DK	NO	6709	.	775.0	18.8	17.6	112.6	5	4.75
42	11	305300	5616950	KOR	DK	NO	7209	.	900.0	22.6	17.9	136.3	5	4.46
42	11	305300	5616950	KOR	DK	NO	7709	.	950.0	25.9	18.6	158.6	5	5.55
42	11	305300	5616950	KOR	DK	NO	8209	.	1150.0	30.5	18.4	186.3	5	6.70

Appendix continued

Plot no.	UTM reference			Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3 ha^{-1} yr^{-1}$)
	Zone	Easting	Northing											
43	11	305300	5616950	KOR	DK	NO	6209	.	425.0	13.6	20.2	87.3	5	2.40
43	11	305300	5616950	KOR	DK	NO	6709	.	450.0	15.4	20.8	99.3	5	2.42
43	11	305300	5616950	KOR	DK	NO	7209	.	475.0	17.1	21.4	111.4	5	2.26
43	11	305300	5616950	KOR	DK	NO	7709	.	500.0	18.7	21.8	122.7	5	2.83
43	11	305300	5616950	KOR	DK	NO	8209	.	550.0	20.8	21.9	136.9	5	3.68
44	11	303800	5604300	KOR	DK	NO	6209	.	525.0	12.6	17.5	73.5	5	2.33
44	11	303800	5604300	KOR	DK	NO	6709	.	575.0	14.5	17.9	85.2	5	2.33
44	11	303800	5604300	KOR	DK	NO	7209	.	625.0	16.4	18.3	96.9	5	2.44
44	11	303800	5604300	KOR	DK	NO	7709	.	725.0	18.5	18.0	109.1	5	2.86
44	11	303800	5604300	KOR	DK	NO	8209	.	775.0	20.7	18.5	123.4	5	3.22
45	11	303800	5604300	KOR	DK	NO	6209	.	250.0	16.1	28.7	111.8	5	2.31
45	11	303800	5604300	KOR	DK	NO	6709	.	275.0	17.8	28.7	123.3	5	2.24
45	11	303800	5604300	KOR	DK	NO	7209	.	325.0	19.6	27.7	134.5	5	2.30
45	11	303800	5604300	KOR	DK	NO	7709	.	350.0	21.3	27.8	146.0	5	3.14
45	11	303800	5604300	KOR	DK	NO	8209	.	425.0	23.8	26.7	161.7	5	3.96
46	11	313700	5605550	BCM	DK	DL	7708	15	435.6	13.0	19.5	78.6	10	4.85
47	11	313500	5605500	BCM	DK	DL	7708	15	455.4	10.9	17.5	61.5	10	4.22
48	10	292750	5621300	BCM	XH	DL	7706	7	237.6	6.4	18.5	37.0	11	3.64
49	11	292850	5621100	BCM	XH	DL	7706	7	316.8	9.1	19.1	53.7	11	3.34
50	10	695050	5633250	BCM	XH	DL	7706	11	455.4	13.4	19.4	80.3	11	3.72
51	10	670000	5640000	BAL	XH	DL	8204	.	1100.0	45.2	22.9	303.5	5	9.54
52	10	670000	5640000	BAL	XH	FS	8204	1	460.0	21.7	24.5	151.5	5	9.23
53	11	298750	5624400	KOR	DK	DL	6709	0	750.0	10.1	13.1	44.3	5	3.57
53	11	298750	5624400	KOR	DK	DL	7209	0	950.0	13.7	13.6	62.1	5	4.41
53	11	298750	5624400	KOR	DK	DL	7709	0	1150.0	18.0	14.1	84.2	5	4.61
53	11	298750	5624400	KOR	DK	DL	8209	0	1200.0	21.9	15.2	107.3	5	4.80
54	11	298750	5624400	KOR	DK	DL	6709	0	300.0	7.3	17.6	39.7	5	1.77
54	11	298750	5624400	KOR	DK	DL	7209	0	350.0	8.8	17.9	48.6	5	2.74
54	11	298750	5624400	KOR	DK	DL	7709	0	500.0	11.5	17.1	62.3	5	3.92
54	11	298750	5624400	KOR	DK	DL	8209	0	800.0	15.5	15.7	81.9	5	4.12
55	10	697000	5656000	BCM	XH	DL	7706	1	396.0	11.2	18.9	66.3	10	5.41
56	10	697000	5656000	BCM	XH	DL	7706	1	524.8	9.9	15.5	53.3	11	3.75

Appendix continued

Plot no.	UTM reference Zone	Easting	Northing	Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3ha^{-1}yr^{-1}$)
57	10	709450	5635800	KOR	DK	NO	6209	.	600.0	5.8	11.1	22.5	5	5.56
57	10	709450	5635800	KOR	DK	NO	6709	.	1050.0	12.1	12.1	50.4	5	6.32
57	10	709450	5635800	KOR	DK	NO	7209	.	1300.0	18.3	13.4	81.9	5	6.03
57	10	709450	5635800	KOR	DK	NO	7709	.	1350.0	23.3	14.8	112.1	5	6.16
57	10	709450	5635800	KOR	DK	NO	8209	.	1400.0	28.1	16.0	142.9	5	6.63
58	10	709450	5635800	KOR	DK	DL	6709	0	200.0	14.4	30.3	99.1	5	2.29
58	10	709450	5635800	KOR	DK	DL	7209	0	200.0	15.9	31.8	110.6	5	2.33
58	10	709450	5635800	KOR	DK	DL	7709	0	200.0	17.4	33.3	122.3	5	2.63
58	10	709450	5635800	KOR	DK	DL	8209	0	250.0	19.3	31.3	135.4	5	3.94
59	10	648800	5631850	BCM	DK	DL	7706	23	425.7	11.4	18.5	64.4	11	2.75
60	10	648500	5631850	BCM	DK	DL	7706	23	306.9	19.1	28.1	128.9	11	2.17
61	10	577000	5772000	BCM	DK	DL	7706	21	505.0	10.0	15.9	52.6	10	4.26
62	10	585000	5759000	BCM	DK	DL	7706	.	653.5	15.6	17.4	87.6	10	3.70
63	10	585000	5759000	BCM	DK	DL	7706	.	326.7	5.5	14.6	27.2	10	2.89
64	10	585000	5759000	BCM	DK	DL	7706	.	405.9	6.7	14.5	33.8	10	3.36
65	10	580000	5756000	BCM	DK	DL	7706	.	405.9	10.1	17.8	57.2	10	3.89
66	10	580000	5756000	BCM	DK	DL	7706	.	346.5	5.9	14.7	29.5	10	2.60
67	10	582000	5748000	BCM	DK	DL	7706	8	267.3	8.7	20.3	51.9	10	2.96
68	10	582000	5748000	BCM	DK	DL	7706	8	277.2	7.6	18.6	44.4	10	3.37
69	10	582000	5748000	BCM	DK	DL	7706	12	396.0	7.8	15.8	41.4	10	3.66
70	10	580000	5756000	BCM	DK	DL	7706	.	673.3	16.5	17.7	89.7	10	3.72
71	10	591000	5734000	BCM	DK	DL	7706	9	336.6	9.0	18.4	53.1	10	2.20
72	10	591000	5734000	BCM	DK	DL	7706	9	297.0	5.5	15.4	27.0	10	2.35
73	10	591000	5734000	BCM	DK	DL	7706	9	227.7	9.2	22.7	57.6	10	2.13
74	10	607400	5727500	LIG	DK	DL	7210	13	66.7	0.6	11.1	3.0	6	2.32
74	10	607400	5727500	LIG	DK	DL	8510	13	440.0	3.9	10.6	16.9	6	2.73
75	10	566000	5767600	LIG	DK	DL	7210	10	383.3	11.9	19.9	75.0	6	3.33
75	10	566000	5767600	LIG	DK	DL	8510	10	678.3	16.0	17.3	95.0	6	4.24
76	10	576000	5745000	LIG	DK	NO	6910	.	846.7	59.6	29.9	453.4	9	4.69
76	10	576000	5745000	LIG	DK	NO	7610	.	980.0	65.5	29.2	495.6	9	5.56
77	10	576000	5745000	LIG	DK	FS	7810	0	500.0	39.9	31.9	302.7	9	4.31
78	10	514300	5742500	BCM	DK	DL	8110	9	333.3	6.9	16.3	36.7	5	3.07

Plot no.	UTM reference Zone	Easting	Northing	Owner*	Biogeoclimatic subzone	Harvest type**	Initial measurement (yr-mo.)	Time since harvest (yr)	Stem frequency (no./ha)	Basal area (m^2/ha)	Quadratic mean diameter (cm)	Volume (m^3/ha)	Measurement interval (yrs)	Volume growth ($m^3ha^{-1}yr^{-1}$)
79	10	575000	5696000	BCM	DK	DL	7708	12	376.2	8.3	16.7	44.6	9	2.54
80	10	575000	5696000	BCM	DK	DL	7708	12	594.1	12.8	16.5	67.0	9	3.55
81	10	595000	5662000	BCM	DK	DL	7708	16	188.1	30.9	45.7	248.6	9	2.45
82	10	627000	8690500	BCM	DK	DL	8109	12	441.7	6.7	13.8	32.2	5	2.65
83	10	625000	5682000	BCM	DK	DL	7708	.	297.0	17.4	27.3	120.8	9	2.64
84	10	625000	5682000	BCM	DK	DL	7708	.	316.8	16.3	25.6	109.2	9	2.44
85	10	627000	5682000	BCM	DK	DL	7708	0	356.4	17.8	25.2	118.8	9	1.22
86	10	627000	5682000	BCM	DK	DL	7708	0	316.8	9.5	19.5	57.1	9	3.25
87	10	602000	5658000	BCM	DK	DL	7708	15	613.9	20.2	20.5	128.1	9	4.29
88	10	602000	5658000	BCM	DK	DL	7708	15	287.1	13.1	24.1	87.3	9	2.89
89	10	618300	5636100	BCM	DK	DL	7708	15	188.1	15.5	32.4	106.2	10	-1.75
90	10	618900	5635450	BCM	DK	DL	7708	15	425.7	17.9	23.1	112.0	10	1.75
91	10	470700	5768300	BCM	DK	DL	8110	17	400.0	8.4	16.3	47.0	5	1.91
92	10	547200	5707000	LIG	DK	DL	7110	9	206.7	7.8	22.0	48.8	6	2.16

* BCM = British Columbia Ministry of Forests
BAL = Balco Ltd.
KOR = R.L. Korol
LIG = Lignum Ltd.

** DL = Diameter Limit Method
FS = Faller's Selection Method
NO = No harvest