

## **Appendix 1 Inventory**

### **Contains:**

- *TFL 56 Inventory Audit Report*
- Chief Forester letter regarding inventory
- Incorrect Forest Type memo
- A Comparison of Growth Intercept and Existing Site Index Calculations



# TFL 56 inventory audit

## Introduction

---

An inventory is conducted by the licensee of each Tree Farm Licence (TFL) in British Columbia every 10 to 30 years, using standards and procedures that are approved by the Ministry of Forests. Regular updates are undertaken to reflect changes in the timber volume due to growth and to depletions from harvesting and natural causes.

This report presents the results of an inventory audit performed within the TFL 56, which is located north of Revelstoke in the southeastern portion of BC. It extends from the Goldstream River in the north towards Mound Revelstoke National park in the south and borders the Revelstoke Timber Supply Area (TSA) to the west and south, TFL 55 to the north and the Golden TSA to the east. The TFL is held by the Revelstoke Community Forest Corporation and is administered by the Columbia Forest District within the Nelson Forest Region.

## Purpose of the audit and application of the results

---

It is often asked, "How accurate is the current inventory?" To answer this important question, the Ministry of Forests has developed an inventory audit methodology specifically designed to test the overall accuracy of estimates of the total standing volume in each timber supply area.

This inventory audit methodology entails sampling three primary components of the inventory: mature forests, immature forests, and non-forest areas.

The objective of the inventory audit program is to help identify TFLs or TSAs where the forest inventory needs attention. Enough samples are taken to ensure statistically reliable results for the TFL as a whole.

The amount of data collected, however, is not sufficient to make statistically reliable conclusions about specific strata within the TFL. For example, any overall differences, highlighted by the audit, could result from problems: with one tree species, from part of the land base (such as high elevation rather than lower elevation areas), from one age group of forest stands, or from a combination of these and other factors. As a consequence, general audit results cannot be used to adjust information for timber harvesting purposes since the audited area represents only a small portion of the

total forested area in the TFL.

The audits provide information that may be useful to the Chief Forester when determining the allowable annual cut—offering a general assessment of the uncertainty associated with mature timber volumes, immature site index, and the non-forest classification. However, the audit results cannot justifiably be used to make specific adjustments to growth and yield and other information used in timber supply analyses and allowable annual cut determinations.

## Methods

---

### Current inventory

There are 35 TFLs in British Columbia, varying in size from approximately 8,500 hectares to 1 million hectares. Inventories of each TFL are conducted through a multistage process. Although the methodology varies within each TFL, all standards must be approved by the Ministry of Forests. New standards currently under development will ensure a consistent minimum standard for all TFLs. Generally, polygons are first delineated from 1:15 000-scale aerial photographs. Photo-interpretation is then used to produce data on a number of attributes for each polygon. These attributes include species composition, stand height, age, and crown closure. Timber volume is then estimated indirectly using the photo-interpreted variables and an empirical yield model. Other approaches to volume estimation, approved by the Ministry of Forests, may also be used.

To keep estimates current, inventories are regularly updated to account for forest growth and for depletions due to harvesting, fire, and the impact of insects and disease damage. Empirical yield models, such as the Ministry of Forests Variable Density Yield Prediction (VDYP) computer model, are used to update the inventory for forest growth. Field visitation, satellite imagery, and aerial photographs may be used to update the inventory for depletions.

### Inventory audit procedures

The inventory audit tests three components of the current inventory. The first component is the mature forested areas (forest stands older than 60 years). The inventory audit tests the accuracy of the mature timber volume. The second component tested is immature stands (younger than 60 years but older than the silvicultural classification of free growing). The audit tests the accuracy of the site growth potential (site





index) assignment for these stands. The third component tested is the area classified as non-forest in the inventory, which includes areas such as lakes, gravel pits, and alpine meadows. The audit tests the accuracy of the photo-interpreted classification for this component.

## Mature component assessment criteria

To test the mature component of the inventory, the existing inventory's estimate of the mean mature volume per hectare for the TFL (the inventory volume), is compared with a new estimate of the mean mature volume per hectare obtained from the audit samples (*the audit volume*). In most TFLs the inventory volume is assessed from base yield curves derived from the VDYP yield model.

The difference between these two estimates is called the total bias. A test is conducted on this bias to determine if it is statistically significant. This test establishes whether there are detectable differences between the audit volume estimate and the inventory volume estimate, for the total forested area of the TFL.

If the total bias is found to be statistically significant, further analyses are conducted to determine if the specific source of bias within the inventory is one of the following:

- *classification bias*: This is caused by incorrectly estimating the polygon attributes; or
- *model bias*: This is caused by poor prediction from the yield model, which was developed for large areas of the province and was not designed for specific management units.

In most TFLs the analysis used to determine the source of bias uses an estimate of the mean mature volume per hectare for the TFL called the ground attribute volume. This is calculated from audit sample attributes (stocking class and stand table estimates of species composition and stocking, and ground-based averages of top height and age), along with crown closure taken from the original map label, using the yield prediction model. The difference between the ground attribute volume estimate and the audit volume estimate approximates the bias associated with the yield model. The difference between the audit volume estimate and the inventory volume estimate not accounted for by the model bias approximates the bias associated with the inventory classification attributes. Once the source is identified, further analyses may be done on the inventory classification attributes or the yield model itself.

## Immature component assessment criteria

Accuracy of the inventory classification for immature stands is tested by examining the site index assignment. Since the immature forest stand site index provides an estimate of site productivity, its accuracy affects the projection of long-term

harvest levels.

Data gathered is examined to determine how closely the audit and inventory site indices match for individual samples, and to explore potential trends.

## Non-forest component assessment criteria

The audit test for the non-forest component of the inventory assesses the accuracy of the non-forest classification assignment. An air photo interpreter certified by the Ministry of Forests compares the non-forest inventory classification to a suitably-scaled forest cover aerial photograph. Classification accuracy is rated using a point scoring scheme to determine an overall accuracy percentage. The acceptance criteria for this test is 85% or higher.

## TFL 56 audit sampling procedures

The TFL 56 sample used updated maps based on the most recent inventory. A list of all polygons identified on the maps was produced and sorted on a number of stand characteristics (site quality, age, and species group). Polygons were systematically selected from this list by a process designed to produce a representative sample of the TFL.

For the mature forested component of the inventory audit, a random sample of 40 forested polygons from the total forested area in the TFL was selected for sampling.

Up to 4 full-measure prism plots and 5 count plots were established within each of the 40 sample polygons. The plots were located systematically, using a square grid and a random start point. The grid interval varied with polygon size. To reduce sample costs for large or irregular polygons, a portion of the polygon was randomly selected for ground sampling. A total of about 160 full-measure and 200 count plots were established. Field data collection and compilation followed Ministry of Forests cruising and cruise compilation procedures. The objective was to obtain audit volumes that were comparable (in terms of utilization standards and merchantability definitions) to the inventory volumes produced from the VDYP model.

Since the licensee used VDYP as their yield model, the audit volumes were compared with inventory volumes generated using VDYP. The VDYP system produces net merchantable volume per hectare, which is defined as stem volume inside bark of all live trees excluding a 10-cm diameter inside-bark top, a 30-cm-high stump, and decay (as estimated from Ministry loss factors). Dead potential and veteran trees are not included in the VDYP estimates. The volume was calculated for a utilization standard defined as all live trees of 12.5+ cm dbh. When considering the audit results, note that differences may exist between the utilization standards applied in the audit and those used operationally.



The audit volume estimates were then compared to the inventory volume estimates (from VDYP) to test the validity of the current inventory. A paired sample t-test was used to test for significant differences. The precision of the inventory volume estimates—how well each inventory volume estimate corresponds to the audit volume estimate on a sample-by-sample basis—was assessed by measuring the statistical correlation. The data was then post-stratified to detect trends related to the operable and inoperable forested land base distribution of the sampled polygons.

From the immature forested component, a random sample of 20 polygons was selected for sampling. Up to 9 inventory ground calls were established within each of the 20 sample polygons. The plots were located systematically, using a square grid and a random start point, similar to the mature volume component. A total of about 180 ground calls were established and data collection followed the standard Ministry of Forests inventory ground call procedures.

To audit the non-forest component, a random sample of 30 non-forest polygons was selected. Standard Ministry of Forests inventory air photo classification techniques were used to compare the 30 non-forest polygon classification assignments to corresponding air photos checks.

## Inventory audit results

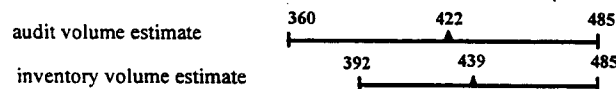
### Analysis of mature volumes

Overall results of the inventory audit for mature volume in the total forested area of the TFL 56 are summarized at the 12.5+ cm dbh utilization limit in Table 1.

TABLE 1. Statistics for the audit volume and inventory volume estimates at 12.5+ cm dbh utilization (net decay), TFL 56

	Audit vol. Estimate	Inventory vol. estimate
Number of samples	36	36
Mean (m <sup>3</sup> /ha)	422	439
Coefficient of variation (%)	44	31
Standard error	30.64	22.96
Sampling error (%)	14.7	10.6
95% confidence interval	360-485	392-485
Correlation coefficient	r = 0.424	
Ratio of means (audit/inventory):	0.96	

#### Bar graph representation of 95% confidence intervals (in m<sup>3</sup>/ha):



The correlation coefficient of 0.424 for the audit and inventory estimates indicates a moderate relationship among the individual samples. There is a 17 m<sup>3</sup>/ha difference

between the mean inventory estimate for mature volume (439 m<sup>3</sup>/ha) and the audit estimate (422 m<sup>3</sup>/ha). A paired-sample t-test determined that this difference is not statistically significant 19 times out of 20 for the mature component of the total forested area of TFL 56. The 95% confidence interval for the mean paired difference is -76 to 44 m<sup>3</sup>/ha. Since there is no statistical difference between the two estimates, the ground attribute volume was not calculated.

In the timber supply process, yield curves from each polygon are aggregated by various methods into a yield curve for each analysis unit, and these analysis unit yield curves are then used to predict volume. To examine this process, volumes derived from the analysis unit yield curves were assigned to each of the audit samples. A paired-sample t-test showed that there was no significant difference between the mean analysis unit estimate and the audit estimate of mature volume.

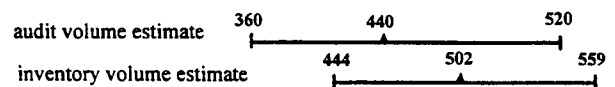
### Analysis of operable and inoperable volumes

To provide audit results more likely to be applicable to the timber supply planning process, an approximation was made of the forested areas considered currently available for timber harvesting (operable areas). The audit results were post-stratified based on this approximation. Results of the inventory audit for samples in the operable forested areas in the TFL 56 are presented in Table 2.

TABLE 2. Statistics for the Operable audit volume, and inventory volume estimates at 12.5+ cm dbh utilization (net decay), operable forested areas, TFL 56

	Operable Audit volume estimate	Operable Inventory volume estimate
Number of samples	17	17
Mean (m <sup>3</sup> /ha)	440	502
Coefficient of variation (%)	36	22
Standard error	37.92	27.21
Sampling error (%)	18.3	11.5
95% confidence interval	360-520	444-559
Correlation coefficient	r = 0.352	
Ratio of means (audit/inventory):	0.88	

#### Bar graph representation of 95% confidence intervals (in m<sup>3</sup>/ha):



For the 17 samples located within the operable forested area, the mean audit volume is 440 m<sup>3</sup>/ha and mean inventory volume is 502 m<sup>3</sup>/ha. The difference of 62 m<sup>3</sup>/ha between the two estimates is not statistically significant 19 times out of 20. Note that the correlation among the samples in the



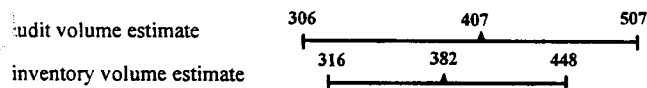
operable forested area was poor (correlation coefficient = 0.352).

There only 19 samples that were located within inoperable forested area. The results of the statistical analysis of the audit for the inoperable area are presented in table 3.

**TABLE 3. Statistics for the audit volume, and inventory volume estimates at 12.5+ cm dbh utilization (net decay), inoperable forested areas, TFL 56**

	Inoperable Audit volume estimate	Inoperable Inventory volume estimate
Number of samples	19	19
Mean (m <sup>3</sup> /ha)	407	382
Coefficient of variation (%)	51	36
Standard error	47.83	31.27
Sampling error (%)	24.7	17.2
95% confidence interval	306-507	316-448
Correlation coefficient	r = 0.472	
Ratio of means (audit/inventory):	1.06	

Bar graph representation of 95% confidence intervals (in m<sup>3</sup>/ha):



For the 19 samples located within the inoperable forested area, the mean audit volume is 407 m<sup>3</sup>/ha and mean inventory volume is 382 m<sup>3</sup>/ha. The difference of 25 m<sup>3</sup>/ha between the two estimates is not statistically significant 19 times out of 20. Due to the relatively high variability associated with these estimates, these results must be viewed with caution.

### Analysis of immature inventory classification

Out of the 20 stands sampled in the field, plots were established in only 18 stands. Of these 18 stands, 4 were too young to assess site index values. In the remaining 14 stands, the inventory correctly identified site index within  $\pm 3$  m of the audit site index for 4 stands. The inventory site index was more than 3 m lower than the audit site index for 4 stands, and more than 3 m higher for 6 stands.

### Analysis of non-forest inventory classification

Thirty stands classified as non-forest were assessed for accuracy of the inventory. The resulting score was 78%, which does not meet the provincial minimum standard of 85%.

## Discussion and conclusions

The objective of the inventory audit in the TFL 56 was to assess the overall accuracy of the current inventory. The mature, immature, and non-forest components were tested.

Audit results for the mature component of the inventory for the TFL 56 suggest that the inventory is statistically acceptable. Subsequent analysis of post-stratified data also shows a similar level of acceptability in the operable forested area.

Audit results for the immature component of the inventory suggest that the site index assignment may not be accurate. Further review of this component of the inventory is required.

The audit assessment of the non-forest classification in this TFL indicates that it did not meet provincial standards. Although, it did not meet provincial standards, it was due to alpine areas that were delineated broadly by current standards and some environmentally sensitive area were described as non-productive forest.

## Glossary

**accuracy:** A measure of how close an estimate is to the true value.

**allowable annual cut:** The rate of timber harvesting specified for an area of land.

**analysis unit:** The basic building blocks around which inventory data and other information are organized for use in forest planning models, typically involving specific tree species or type groups that are further defined by site class, geographic location or similarity of management regimes.

**bias:** The quality of a measurement device or procedures that tends to result in a systematic misrepresentation of what is being measured.

**coefficient of variation:** A relative measure of variation within a population, calculated as the ratio between the standard deviation and the mean value.

**confidence interval:** The range of values within which the population parameter is expected to lie.

**confidence level:** The estimated probability that a population parameter lies within a given confidence interval.

**correlation coefficient:** A measure of the relationship between two variables. A value of 0 for the correlation coefficient indicates a random relationship, whereas a value of  $\pm 1$  indicates a perfect positive or negative linear correspondence.

**dead potential trees:** Standing or down dead timber which is estimated to contain at least 50% of its original gross



volume in sound wood.

**diameter at breast height (dbh):** The stem diameter (outside-bark) of a tree measured at breast height (1.3 metres above the point of germination) to the nearest millimetre.

**field visitations:** Ground-level field procedures designed to provide physical verification of polygon inventory attributes.

**free-growing (crop):** A crop of healthy trees of a commercially valuable species, the growth of which is not impeded by competition from plants, shrubs, or other trees.

**inoperable lands:** Lands that are unsuited for timber production now and in the foreseeable future because of their topography, inaccessible location, low value of timber stands, or designation for uses incompatible with timber production.

**mean:** The average value of a set of observations.

**polygon:** A portion of land area, delineated on mid-scale aerial photographs, of "like" or uniform land cover type.

**pre-inventory assessments:** Inventory activities to evaluate the existing forest inventory as a basis for deciding whether to re-inventory or update the current inventory, and to document the existing inventory, maps, and photos to support the execution of the reinventory or update if required.

**public sustained yield units (PSYU):** A portion of a TSA; an area of Crown land, usually a natural topographic unit determined by drainage areas, managed for sustained yield by the Crown through the Ministry of Forests. It includes all Crown lands within the currently established boundaries of the unit and excludes federal lands, provincial parks, experimental forest reserves, gazetted watersheds and tree farm licenses.

**ratio estimate:** The ratio between two different estimates.

**representative:** The quality of a sample having the same characteristics as the population from which it is selected.

**sampling:** The process of selecting observations.

**sampling error:** The error attributed to sampling procedures.

**significant difference:** The results of a statistical test comparing either two or more estimates, or an estimate to a fixed value. If the difference is too large to be

attributed to chance, the difference is said to be statistically significant.

**site index:** An expression of the forest site quality of a stand, at a specified age, based either on the site height, or on the top height, which is a more objective measure.

**standard error:** An expression of the absolute variability of an estimate.

**standard deviation:** A measure of the variation of the population.

**timber supply analysis:** An assessment of future timber supplies over long planning horizons (more than 200 years) by using timber supply models for different scenarios identified in the planning process.

**timber supply area (TSA):** An area defined by an established pattern of wood flow from management units to the primary timber-using industries.

**tree farm license (TFL):** Privately managed Sustained Yield Units; designed to enable owners of Crown-granted forest lands and old temporary tenures or the timber licenses which replace them, to combine these with enough unencumbered Crown land to form self-contained sustained yield management units.

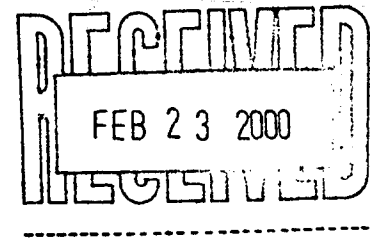
**variable density yield prediction (VDYP) model:** An empirical yield-prediction system for natural stands based on data collected in temporary inventory sample plots (TSPs) and natural, permanent growth sample plots (PSPs). VDYP predicts volume (net decay) and diameters at four utilization levels using stand height, age, and density. The aerial approach uses crown closure as the density measure.

**veteran trees:** Mature living trees which are remnants of an older stand.

## For more information

For more information or to obtain other inventory audit reports, contact: Director, Resources Inventory Branch, 722 Johnson Street, Victoria, BC, Canada V8W 3E7, Phone 250-387-1314, fax 250-387-5999, or visit our web site at <http://www.for.gov.bc.ca/resinv/>

February 1999



File: 19710-30/TFL 56 MP 3

February 21, 2000

Del Williams, RPF  
Operations Forester  
Revelstoke Community Forest Corporation  
P.O. Box 3199  
216 Mackenzie Avenue  
Revelstoke, British Columbia  
V0E 2S0

Dear Del Williams:

Thank you for your letter dated July 20, 1999, requesting confirmation that a comprehensive inventory not be required for Management Plan (MP) No. 3 of Tree Farm Licence (TFL) 56. I apologize for the delay in my response.

Based on the results of the TFL 56 inventory audit (January 1999), I accept the existing forest cover inventory for use in the upcoming timber supply analysis for MP No. 3. However, I am still concerned about the age and reliability of the forest cover data. For example, I note that the audit indicates potential discrepancies with site indices of immature polygons and the classification of non-forest.

I request that you complete a thorough assessment of the forest cover inventory in conjunction with regional and provincial inventory staff. The assessment should evaluate your existing inventory against current inventory standards. The MP must also commit you to an action plan that will prioritize and resolve any outstanding concerns. The action plan will form part of the MP commitments to be met over the term of MP No. 3.

I anticipate that the forest cover inventories used in MP No. 4 will provide an improved base for future planning and timber supply analysis.

I acknowledge recent work by the Revelstoke Community Forest Corporation on other requirements, including terrain stability mapping and stream classification for TFL 56, and note these will be used in the current timber supply analysis.



Page 1 of 2

• THE GOVERNMENT OF BRITISH COLUMBIA IS AN 'EMPLOYMENT EQUITY EMPLOYER' •

**Ministry of  
Forests**

Ministry Executive

Location:  
4th Floor, 595 Pandora  
Avenue

Mailing Address:  
P.O. Box 9525 Stn Prov Govt  
Victoria, BC V8W 9C3

Tel: (250) 387-1296  
Fax: (250) 387-6267

Should you have any questions, please contact Cal Hauk in the Nelson Regional Office at (250) 354-6246.

Yours truly,

A handwritten signature in black ink, appearing to read 'L. Pedersen', with a long horizontal flourish extending to the right.

Larry Pedersen  
Chief Forester

pc: David Raven, District Manager, Columbia Forest District  
Cal Hauk Resources Inventory Manager, Nelson Forest Region  
Gerry Reichenback, Timber/Issues Forester, Nelson Forest Region  
Keith Tudor, Resources Inventory Branch  
Jeff Stone, Timber Supply Analyst, Timber Supply Branch



---

---

**MANAGEMENT PLAN #3 MEMORANDUM**

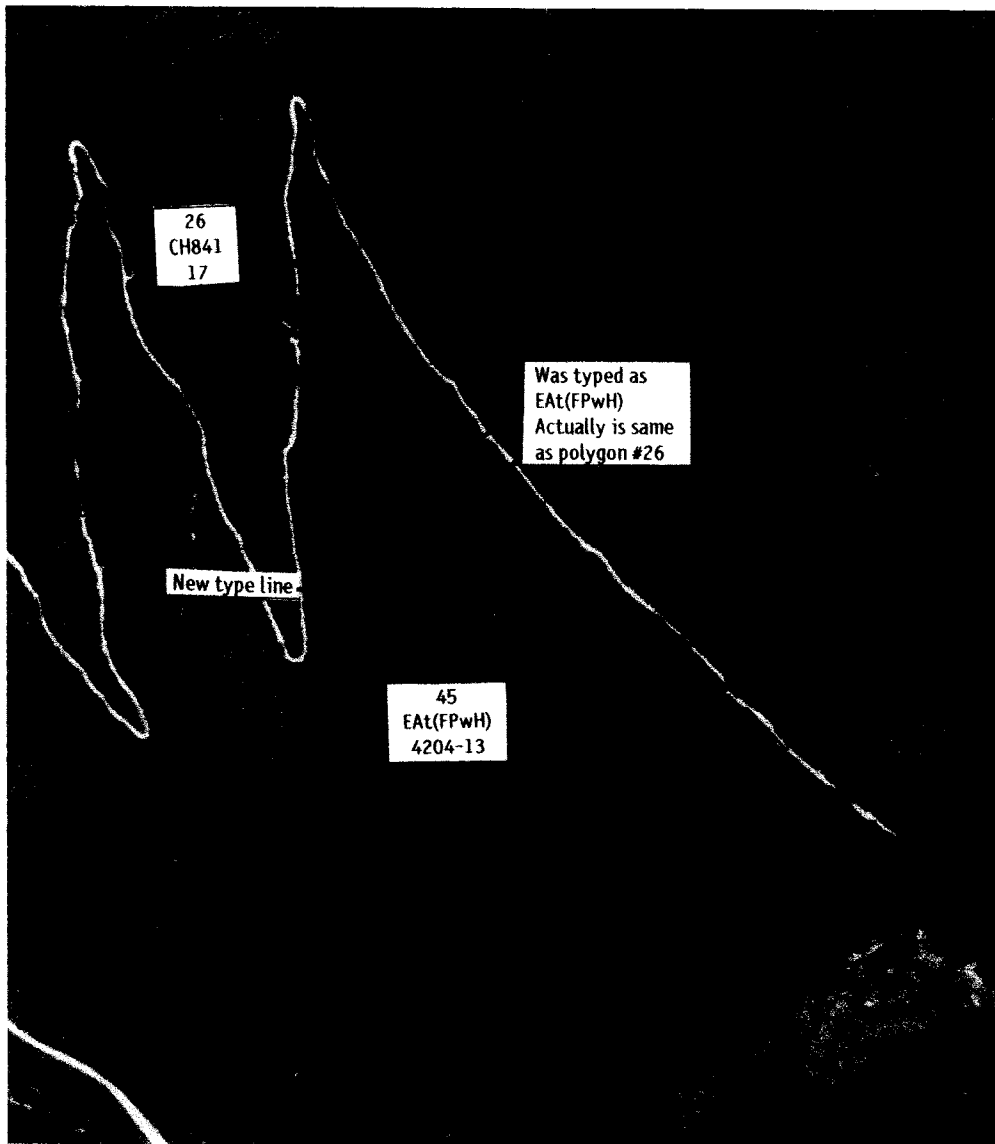
---

---

**TO:** INFORMATION PACKAGE REPORT  
**FROM:** DEL WILLIAMS R.P.F.  
**SUBJECT:** INCORRECT FOREST INVENTORY TYPE  
**DATE:** MARCH 24, 2000

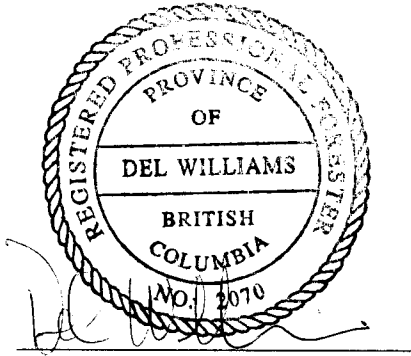
---

An incorrect forest type was discovered when doing the net-down analysis. A sizeable area was typed as deciduous-leading, which would cause that area to be netted out of the analysis. The actual forest type is CH841, the same as an adjacent polygon.



To correct the error, we will have the area retyped at the time of the next inventory update. In the meantime, for our timber supply analysis, we will use the data from the adjacent polygon (82M039-26) to substitute for the portion of the affected polygon that is mistyped (82M039- 45).

The mistyping is shown on the preceding excerpt from the orthophoto. It is quite obvious that the stand in question is not a birch/aspen stand. It is part of the same stand type that is now polygon 26.



Del Williams R.P.F.

# A Comparison of Growth Intercept and Existing Site Index Calculations

March 2000

Revelstoke Community Forest Corporation - TFL No. 56

Map Sheet	Polygon	OPENING C.P. Block	Site	SURVEY YEAR	HA.	G.I. S.I.	Species	Old S.I.*	Change %
82M048	211	688-4	A	1998	34.5	23	FDi	17	35%
82M048	129	690-17	A	1999	32.0	30	FDi	17	76%
82M048	135	690-2	A	1998	50.4	27	FDi	17	59%
82M048	86	690-300	A	1999	18.3	21	Cw	10	110%
82M049	100	690-9	A	1999	22.3	21	Sx	15	40%
82M048	502	692-103	A	1998	58.1	25	FDi	10	150%
82M059	472	698-6	A	1999	14.1	24	Sx	15	60%
82M059	614	700-4	A	1999	8.7	27	Sx	10	170%
82M059	705	700-5	A	1999	13.8	25	Sx	15	67%
82M068	53	724-101	A	1997	3.0	18	Hw	18	0%
82M068	2106	724-1A	A	1997	7.8	17	Hw	19	-11%
82M068	113	724-2A	A	1998	64.6	21	Sx	19	11%
82M068	57	724-3	A	1997	40.7	26	Se	19	37%
82M068	2113	724-301	C	1999	15.5	21	Sx	19	11%
82M068	145	724-302	A	1997	174.4	16	Hw	18	-11%
82M068	109	724-304	B	1999	35.0	18	Cw	19	-5%
82M058	32	726-10	A	1997	68.8	22	Se	20	10%
82M068	515	726-17	A	1999	34.8	16	Bl	11	45%
82M068	423	726-6A	A	1997	34.4	20	Se	15	33%
82M068	471	726-8	A	1997	21.6	25	Se	18	39%
82M068	567	726-9	A	1998	23.6	18	Sx	19	-5%
82M068	178	728-200	A	1999	40.4	20	Cw	13	54%
<b>Totals and averages:</b>					<b>816.8</b>	<b>21.9</b>		<b>16.0</b>	

Percent increase in site index estimate: 36.3%

\* Old site index retrieved from archived inventory files

This 36% increase in site index would apply only to those stands that have already been logged (ie. OGSi does not apply) and have not had a new site index assigned through SIBEC or Growth Intercept methods. It assumes that these managed stands are still using the old growth site index value. The increase applies to approximately 6693 ha (32%) of the THLB (7454 ha of THLB logged less 761 ha with updated SI's).