BRITISH COLUMBIA

Ministry of Forests, Lands and Natural Resource Operations

Timber Pricing Branch

MEMORANDUM

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July 23, 2013

BY EMAIL

To: Regional Executive Directors

From: Grant Loeb
A/Director
Timber Pricing Branch

Re: 2013 *Cruise Compilation Manual - Errata*

The purpose of the memo is to inform you that the previous memorandum dated July 22, 2013, contained an inconsistency in the transition period for the 2012 compilation program. Please replace the previous memorandum with this one.

Cruise Compilation Manual and *CGNF Compilation Manual* for the Coast Forest Region become effective on July 22, 2013.

The new manual will be available on the internet at the following link:

http://www.for.gov.bc.ca/hva/manuals/cruisecompilation.htm; and

http://www.for.gov.bc.ca/hva/manuals/cgnfcompilation.htm

Cruises compiled with version 2012.00 before July 22, 2013, will be allowed for appraisal cruises until November 1, 2013. See the additional information regarding the valid compilation versions at the following web link:

http://www.for.gov.bc.ca/hva/manuals/validcompversions.htm

Please find a copy of the 2013 *Cruise Compilation Manual* and *CGNF Compilation Manual* Highlights attached.

Comments or questions about this manual should be referred to Beth Eagles, Cruising Policy Forester, Timber Pricing Branch at (250) 387-8307 or Don Rorison, Cruising Projects Specialist, Timber Pricing Branch (250) 356-7674.

We apologize for any inconvenience this may have caused.

Grant Loeb
A/Director
Timber Pricing Branch

Attachment

Regional Executive Directors

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TIMBER PRICING BRANCH

CGNF Compilation Standards for the Coast Forest Region

July 22, 2013

BRITISH COLUMBIA

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Highlights

The *CGNF Compilation Standards for the Coast Forest Region Manual* is available on the Internet at:

http://www.for.gov.bc.ca/hva/manuals/cgnfcompilation.htm

Section	Description
All Reports	The 2013 version number will be reported as 2013.00 on all of the cruise compilation reports.
CGNF Compilation Chapter 2, Page 2-4	Edit Errors are implemented for dead potential and dead useless trees.
CGNF Compilation Appendix 5	The coast spruce high grade historic grade percentages are rolled up for April 1, 2011 to March 31, 2013 for use in the grade algorithm for call grade net factor (CGNF) cruises.

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Introduction 1

The *Call Grade Net Factor (CGNF) Manual* has been developed to document the CGNF compiler process for MOF appraisal purposes. Where not specifically noted in this manual, all standards and procedures currently in the Cruise Compilation Manual will be followed.

The intent of this section is to provide an overview of CGNF as it applies to appraisal cruises.

CGNF uses cruiser estimates of decay, waste and value (grades) for individual logs in a tree. There are no risk groups used in CGNF. The cruiser estimates the quality of each log using the Coast Scaling alpha grades. These grades are called using preferred lengths of 13, 11 and 8 metres. Random lengths are permitted for deformities in the stem and for the last log.

Pathological remarks, tree classes and age in tens are replaced with tree maturity codes for mature and second growth and tree code live and dead.

The log volume formula used in this manual is Smalian's formula using 10cm segments.

The net volume principles, procedures and standards will be fine tuned through an unbiased net volume adjustment process that will be applied as post-cruise compilation factors known as species net volume adjustment factors (NVAF). As part of the NVAF process, the gross taper has been adjusted by applying a volume adjustment. These two processes have been separated but in the end the goal is to provide the best estimate of net volume based on the data available. See Chapter 3.1, step 3 for equations and Appendix 1, step 3 for an example.

The compiler process for volume deduction is as follows:

1. The original gross volume is adjusted by the gross taper volume ratio.

2. Each log's net factor is adjusted by the NVAF process to calculate the final net volume by log.

The last log of a tree is calculated based on the minimum length of the grade of the log. If the last log is shorter than the minimum length specified for the logs grade, the last log

is combined with the second to last log and takes on the grade of the second to last log. See Appendix 1 step 2.4 for an example.

1.1 All Reports

The differences between the Call grading net factoring and the loss factor systems will necessitate changes to some reports.

All reports will require the following similar changes.

- All summaries will report Call Grading Net Factoring in the header.
- All live trees will be coded "L" and replace tree classes 1 ,2, 5, 8.
- All dead trees will be coded "D" and replace tree classes 3, 7, 9.
- There is no designation for useless trees in the CGNF compiler. The trees are not tallied in the cruise and will not be reported (tree classes 4 and 6).
- Snags/ha and Average Snag DBH are not reported.
- Immature % is the sum of net volumes of all trees (coniferous and deciduous) with tree code 'S' (second growth) divided by the total net volume of all trees (coniferous and deciduous). Use the loss factor cruise Card Type D block maturity indicator for the loss factor and the CGNF cruises in the transition period from loss factor to CGNF cruising.
- Second growth % is the sum of all coniferous net volumes with tree code 'S'(second growth) divided by the total net volume of all coniferous trees.
- Short trees that have only one log less than 3.0 metres will not be included in the compilation. A line at the bottom of reports should indicate the number of trees removed from the compilation. There is no requirement to report these trees as useless (tree class 4 or 6) since CGNF cruises do not report useless trees. Since short trees that have only one log less than 3.0 m were cruised, these trees will be included in the cruised trees/plot field.
- Decay % is corrected decay volume/corrected gross volume.
- Z grade logs will be compiled as waste volume. When a tree is coded as Z-99-00 then no values will be reported for that stem.
- Waste percent is the corrected waste volume/corrected gross volume.
- Breakage percent will report the newly update breakage % for CGNF based on the loss factor breakage percentages. Breakage % is unadjusted breakage volume/corrected gross volume. See Appendix 3.
- PSYU and Unit # are not required.

1.2 Required Reports

1.2.1 Plot Summary

- Loss factor reference numbers are not required.

1.2.2 Cruise Statistics

- Useless trees are not reported.

1.2.3 Stand, Stock, and Basal Area Reports

- Useless trees are not reported.
- Live trees (tree code "L") are reported by species in the tables and in Total column.
- Dead trees (tree code "D") are reported in the DP column.

1.2.4 Volume Summaries

- Snags/ha and Avg. Snag DBH fields are not reported.
- Decay percent (%) field is calculated using cruiser net factoring estimates.
- Waste percent (%) field is calculated using the cruiser estimated Z grade waste less decay less breakage volume.
- Waste (billing) percent is not required.
- Breakage percent (%) field is calculated using the CGNF breakage table
- Average 10 metre log gross or net fields are not required.
- Average number (#) of 10 metre logs/tree field is not required.
- Alpha grades will summarize by nearest 1%. Grades include: B, C, D, E, F, G, H, I, J, K, L, M, U, X, and Y. Z grades will be reported using the waste percent (%) field. When a tree is coded as Z-99-00 then no values will be reported for that stem. N grade (nothing there) is collected by the cruiser but is not reported for net volume.

1.2.5 Harvesting Method Summary

- Decay % field is calculated using cruiser net factoring estimates.
- Waste percent (%) field is calculated using the cruiser estimated Z grade waste less decay less breakage volume.

- Waste (billing) % is not required.
- Average 10 metre log gross or net fields are not required.
- Useless Dead/ Living field is not required.
- Net second growth percent (%) field is calculated using the maturity tree code "S" to calculate the percentage of second growth trees. Only coniferous trees are used to summarize the net second growth %.
- Alpha grades will summarize by nearest 1%. Grades include: B, C, D, E, F, G, H, I, J, K, L, M, U, X, and Y. Z grades will be reported using the waste % field. When a tree is coded as Z-99-00 then no values will be reported for that stem. N grade (nothing there) is collected by the cruiser but is not reported for net volume.

1.2.6 Appraisal Summaries

- Alpha grades will summarize by nearest 1%. Grades include: B, C, D, E, F, G, H, I, J, K, L, M, U, X, and Y. Z grades will be reported using the waste percent (%) field. N grade (nothing there) is collected by the cruiser but is not reported for net volume.
- Net volume/10 metre log is not required.
- Cruised trees/plot will summarize all trees cruised. The cruised trees will include short trees that are not compiled.
- Net second growth percent (%) field uses tree code "S" to calculate the percentage of second growth trees. Only coniferous are used to summarize the net second growth %

1.2.7 Percent Reduction Report

- Block field is not required. Block reductions are unavailable for use at this time.
- Tree class is not required. Tree class is not available in CGNF cruises.
- Species, Type, Treatment unit and damage are available for reduction purposes.
- Maturity field may be reported. The maturity field is available for CGNF cruises.
- Live/Dead field may be reported. The Live/Dead field is available for CGNF cruises.

1.2.8 Extended Forest Type Stand and Stock Reports

- This report is not required in CGNF cruise compilations.

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Data Input and Edits 2

2.1 Data Inputs

The data collection requirements have changed for CGNF. Loss factors are not used to calculate net volume and the MOF grading algorithm is not used to calculate log grades. Therefore, pathological remarks, tree class, age in tens, and quality remarks are not recorded by the cruiser. Instead, for each log, the cruiser assigns the grade, log length and net factor (estimate of sound wood volume as a percent).

Card	Column	Attribute	New Codes	Error
A	18	Unit type	Blank	NA
A	19-20	Unit number.	Blank	NA
A	21	Block	Blank	NA
A	27	Tenure	Blank	NA
A	28	Quota	Blank	NA
A	29	Sale Type	Blank	NA
B	17-18	Type of Compilation	32	F
B	28-29	Log Length	13m	I
B	43-44	Log Length	13m, Blank	I
B	58-59	Log Length	13m, Blank	I
B	73-74	Log Length	13m, Blank	I
B	76	Grade Type	C (CGNF), Blank (computerized)	F
9	21-22	Age in Tens	Blank	NA
2	36	Tree class	Blank	NA
2	37	Conk	Blank	NA
2	38	Blind conk	Blank	NA
2	39	Scar	Blank	NA
2	40	Fork or crook	Blank	NA
2	41	Frost crack	Blank	NA
2	42	Mistletoe	Blank	NA
2	43	Rotten branch	Blank	NA
2	44	Dead or broken top	Blank	NA
2	45	Spiral grain	Blank	NA
2	46	Sweep	Blank	NA
2	47	Lean	Blank	NA
2	48	Live limb	Blank	NA
2	49	Stub	Blank	NA
2	50	Knots in 1st 5m log	Blank	NA
2	51	Knots in 2nd 5m log	Blank	NA
2	60	Root Rot	J,K,L, Blank	F

Card	Column	Attribute	New Codes	Error type
2	61	Insect	1, 2, 3, 4, 5, 6, 7, 8, X, Y, blank	F – (species specific)
2	62	Fire	A,B,C, Blank	F
2	63	Blowdown	E, G, Blank	F
2	64	Mature/ Second Growth	M, S	F
2	65	Live/Dead	L, D	F
2	66	Log 1 Grade	B-Z	F
2	67-68	Log 1 Length	1-99	F
2	69-70	Log 1 Net Factor	0-99, -	F
2	71	Log 2 Grade	B-Z, Blank	F
2	72-73	Log 2 Length	1-99, Blank	F
2	74-75	Log 2 Net Factor	0-99, -	F
2	76	Log 3 Grade	B-Z, Blank	F
2	77-78	Log 3 Length	1-99, Blank	F
2	79-80	Log 3 Net Factor	0-99, - Blank	F
2	81	Log 4 Grade	B-Z, Blank	F
2	82-83	Log 4 Length	1-99, Blank	F
2	84-85	Log 4 Net Factor	0-99, - Blank	F
2	86	Log 5 Grade	B-Z, Blank	F
2	87-88	Log 5 Length	1-99, Blank	F
2	89-90	Log 5 Net Factor	0-99, - Blank	F
2	91	Log 6 Grade	B-Z, Blank	F
2	92-93	Log 6 Length	1-99, Blank	F
2	94-95	Log 6 Net Factor	0-99, - Blank	F
2	96	Log 7 Grade	B-Z, Blank	F
2	97-98	Log 7 Length	1-99, Blank	F
2	99-100	Log 7 Net Factor	0-99, - Blank	F
2	101	Log 8 Grade	B-Z, Blank	F
2	102-103	Log 8 Length	1-99, Blank	F
2	104-105	Log 8 Net Factor	0-99, - Blank	F
2	106	Log 9 Grade	B-Z, Blank	F
2	107-108	Log 9 Length	1-99, Blank	F
2	109-110	Log 9 Net Factor	0-99, - Blank	F
2	111	Log 10 Grade	B-Z, Blank	F
2	112-113	Log 10 Length	1-99, Blank	F
2	114-115	Log 10 Net Factor	0-99, - Blank	F

Notes:

1. The PSYU information is not required since the loss factors are not used for CGNF compilations.

2. Attributes from age in tens, tree class, pathological remarks and quality remarks are not required for CGNF compilations.

3. At least one log grade must be recorded per tree starting at log 1.

4. The last log is signified by a "99" in the log length. No other log length in a tree should have log length "99".

5. The net factor of "—"or"-" signifies no decay in the log.

6. Species codes are requested for Mountain Hemlock (HM) and Western Hemlock (HW). A code of H will be considered Western Hemlock.

7. Live/Dead – Position 64 on the tally card: Produce an edit error if CGNF code L (live trees) does not match tree classes 1, 2, 5, 6, 8 and code D (dead trees) does not match tree classes 3, 7, 9. This edit applies to both loss factor and CGNF compilations.

8. Dead Tree Class 3, 7, 9 Trees: Produce an edit error if the tree does not contain at least eight consecutive meters of U-grade or better logs or Z-99-00. The tree will be included in the cruise volume if it contains at least 8m of U-grade. If the tree is coded Z-99-00, then it will be included in the CGNF waste percent. This edit applies to CGNF compilations.

9. Dead Tree Class 4 Trees: Produce an edit error if the tree does not contain at least eight consecutive meters of U-grade or better logs. The tree will be included in the cruise volume if it contains at least eight consecutive meters of U-grade or better logs. The tree will be removed from the compilation if it does not contain at least contain at least eight consecutive meters of U-grade or better logs. This edit applies to both loss factor and CGNF compilations.

* Live Useless Tree Class 6 – An edit error is not required because the minimum 8m U-grade standard does not apply to live useless trees. These trees will be compiled in the snag percent in the loss factor cruise.

2.2 Validation Errors and Warnings

Unless specifically noted in this chapter the errors and warnings stated in the Cruise Compilation Manual also apply to CGNF compilations.

2.2.1 Errors

Grades, net factors and log lengths must be validated. If the log information does not meet the standards as found in Appendix 2, a validation error will be issued.

There is an exception for helicopter logging which has a minimum log length standard of 4 metres instead of 5 metres used in conventional logging.

An error should be produced when the cumulated log lengths is greater than the merchantable height. Example:

Species	W.R. Cedar	Log #	Grade	Log len (m)
DBH	120.0 cm	1	F	8
Total Height	32.0 m	2	H	13
F.I.Z.	C	3	J	8
Stump height	30 cm	4	U	8
Top diameter	15.0 cm	5	Y	99

Determine the merchantable height of the tree. For this example merch ht = 26.4 m.

Sum up the called log lengths starting from the first log (8+13+8+8m) = 37 m.

Since, the merch ht of the tree is only 26.4 m, the sum of the called log lengths of 37 m is greater and therefore, a validation error is produced. The compiler should check that the height or that the log lengths are correct.

2.2.2 Warnings

Top/Butt diameters must be validated that they are within acceptable limits. For instance a Douglas Fir D grade log that has a 10cm top diameter would not qualify as D grade. The compiler must ensure that each log is verified using a lookup table that provides acceptable top diameters by grade and species. Valid top diameters by grade and species as well as minimum log lengths and net factors per grade are shown in Appendix 2.

The top diameter of the logs will be given a fifteen percent (15%) allowance as compared to the taper equation. If the logs' compiled top/butt diameter has a greater than fifteen percent (15%) difference, a warning message will be issued.

The standard log length is 13 m. Preferred log lengths of 13, 11 and 8 metre lengths will also be called by the cruisers for individual logs. Any log length from 3 to 17 metres and 99 will be permitted for log grades B to Y. All "Z" or "N" grade logs may have cruised lengths greater than or equal to 1m, in 1m increments. However, when compiling the last logs, Z and N grade logs can have any length.

2.2.3 Examples

Example #1:

For a Douglas-fir with Grade B: log length: 4.0 m, top diameter: 50 cm, net factor: 75%. Both examples have conventional harvest methods.

The validation errors and warnings for this tree are:

Log Attribute	Minimum Requirement	Actual Log Example	Comments	Error/Warning Message
Grade		B	Grade B is permitted for Douglas-fir.	**None**
Log Length	5 m	4 m	B grade must be greater or equal to 5 m in length.	**Error**
Min Top Diameter	60 cm	50 cm	60 cm * (1-15%) = 51.0 cm. For diameters, a ± 15% threshold is permitted. Since the log is 50 cm, this log is outside of the range.	**Warning**
Max Top Diameter	9999 cm (no limit)	-	There is no max top diameter for this grade.	**-**
Minimum Percent Recoverable	80 %	75 %	B grade must be greater or equal to 80 % net factor.	**Error**

Example #2:

For a Douglas-fir with Grade 1: log lenth: 8.0 m, top diameter: 38 cm, net factor: 70 %

The validation errors and warnings for this tree are:

Log Attribute	Minimum Requirement	Actual Log Example	Comments	Error/Warning Message
Grade		I	Grade I is permitted for Douglas-fir.	**None**
Log Length	5 m	8 m	Log > = 5 m.	**None**
Min Top Diameter	38 cm	38 cm	Within range.	**None**
Max Top Diameter	9999cm (no limit)	-	There is no max top diameter for this grade.	**-**
Min Net Factor	38-50 cm top diam; min NF = 75% > = 50 cm top diam; min NF = 50%	70 %	Since top Diam. = 38 cm, the min NF% permitted is 75%. Since the log has a NF % of 70 %, the log can't be an I grade because of size of the top diameter.	**Error**

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Compilation Sequence 3

3.1 Log Volume Calculation - Overview

See Appendix 1 for examples of detailed tree and log volume calculations.

When a tree is coded as Z-99-00 then no values will be reported for that stem.

Step 1 Set the parameters for calculating the taper and volume of a tree. These are:

1. Forest Inventory Zone.
2. DBH - Diameter at breast height (1.3 m) outside bark and above high side ground to the nearest tenth of a cm (e.g., 110.1).
3. Height - Total height to the nearest tenth in metres (e.g., 41.3).
4. Stump ht. - Stump height to the nearest hundredth in meters (e.g., 0.30).
5. Top diam. - Top diameter inside bark to the nearest tenth in cm (e.g., 10.0 or 15.0 cm).
6. Log length – individual log lengths called by cruiser. Preferred log lengths are 13, 11 and 8 m. Random lengths can be called. Maximum compiled log length is 17.9 m (13 m + 4.9 m minimum log length for a recorded last log of 99).

Step 2 Calculate tree volumes using the taper equation and volume routine (see Appendix 1).

Use the taper equation and volume routine with the above defined parameters.

These routines will determine:

1. The diameter inside bark at stump height.
2. The merchantable height of the tree.
3. The length of the last log. If top log length is less than the minimum log length for that species and grade, then the last log is combined with the second to last log and assigned the second to last log grade. The net factors are then combined. See Appendix 1 step 2.3.
4. Calculate the new net factor for the last log (only required if the last log is combined with the second to last log). See Appendix 1 step 2.4.
5. Calculate top and butt diameters for each log.
6. Calculate gross merchantable volume using Smalian's formula for

each log. Calculate Smalian's volume using a 10 cm segment length.

7. Biological volume – from high side ground to top of tree. Gross merchantable volume + stump volume + top volume.

Step 3 Apply net downs. Cruiser estimated net factors by log for decay volume, cruiser called Z grades for waste volume, CGNF lookup table for breakage volume (see Appendix 3), and NVAF corrections for taper and decay (see Appendix 4).

Terms:

Fb	Breakage Factor
Ft	Taper Correction Factor
Fr	NVAF Correction Ratio
Fd	Decay Factor
Fdc	Tree Decay Factor after NVAF Correction
B	Breakage Volume
D	Decay Volume
W	Waste Volume
V	Gross Volume
VmB	Gross Volume minus Breakage
VmBc	Gross Volume minus Breakage after Taper Correction
VmBDc	Gross Volume minus Breakage and Decay after NVAF Correction
Vn	Net Volume (Gross Volume-Breakage-Decay-Waste)
Vc	Gross Volume after Correction
N	Number of Logs

1. For each log, calculate the Log Breakage Volume. The NVAF process did not include breakage volume; therefore, the breakage volume must be taken out before the remainder of the volume is adjusted.

   $$B_i = V_i \; x \, Fb$$

2. Log Gross Volume minus Breakage is:

   $$VmB_i = V_i \, (1 - Fb)$$

3. Apply the Taper Correction Factor. The taper correction is used to correct the known bias in the gross volume of taper equations. These factors are corrected by species, maturity and live/dead (see Appendix 4).

   $$VmBc_i = VmB_i \; x \, Ft$$

4. The corrected Gross Volume is:

   $$Vc_i = VmBc_i + B_i$$

5. Calculate Tree Decay Factor by taking the average of logs Decay Factor weighted by the log volumes in step 3 above.

   $$Fd = \frac{\sum_{i=1}^{n} \left(Fd_i \; x VmBc_i \right)}{\sum_{i=1}^{n} VmBc_i}$$

6. Correct the Decay Factor using the NVAF coefficients from the lookup table:

   $$Fdc = Fr \times Fd^{\,Fp}$$

7. The log's Decay Factor is adjusted by the NVAF factor calculated in 6 above, to deduct the Decay volume:

   $$VmBDc_i = VmBc_i \times Fd_i \times \frac{Fdc}{Fd}$$

8. The Decay volume is:

$$D_i = VmBc_i \times (1 - Fd_i \times \frac{Fdc}{Fd})$$

9. If the log is of the Z grade:

$$Vw_i = VmBDc_i$$

$$Vn_i = 0$$

otherwise:

$$Vw_i = 0$$

$$Vn_i = VmBDc_i$$

10. The tree's Net Volume is:

$$Vn = \sum_{i=1}^{n} Vn_i$$

Step 4 If a percent reduction is being compiled, determine whether there is an eligible reduction for the tree. Refer to *Chapter 5* for the Percent Reduction procedures. Risk group/tree class is not used in CGNF. However, Dead/Live and Mature/Second Growth tree codes can be used.

Step 5 If both count and measure plots have been tallied in a variable plot cruise, calculate a double sampling ratio (DSR) for each tallied species. The DSR adjusts stem count, basal area, and volume estimates. Calculate a DSR for each Timber Type.

Output - Double Sampling Ratios (004b).

Example: Fir DSR for a Timber Type

$$\mathrm{DSR}_{(\mathrm{fir})} = \frac{\#\,\text{of meas plots.}}{\text{Total}\,\#\,\text{of plots}} \quad * \quad \frac{(\#\,\text{fir trees}) * (\text{avg. BAF all fir trees})}{(\#\,\text{meas. fir trees}) * (\text{avg. BAF meas. fir})}$$

To calculate the average BAF , sum the basal area per hectare of all the trees in the type and divide by the number of trees in the type.

Step 6 Double the volume, basal area and tree count for border plots used in cruises conducted prior to 2005.

Step 7 Calculate grade percents. Each log grade, length and net factor is assigned by the cruiser.

Spruce high grades F and G are called by the cruiser and a lookup table is used to breakout grades D and E. See Appendix 5.

3.2 Calculating Volumes Using Smalian's Formula

CGNF uses Smalian's formula for calculating log volumes. Segment length is 10cm.

To calculate a tree's merchantable volume for cruiser called grades, simply calculate and accumulate each individual called log volume. Care must be taken for the total length of the logs not to exceed the merchantable height. See Chapter 2 - 2.2.1 Validations for an example.

To calculate a tree's **merchantable height**, you can use a method resembling the binary search algorithm. Starting with an initial value for the merchantable height, calculate the DIB and compare it with the standard top diameter. If not equal, adjust the height and recalculate the DIB in a loop until the difference between the standard and the calculated diameter is negligible. See Appendix 1, step 2.2 Example #1. Version 4.1 of Kozak's taper equation is used to calculate the diameter inside bark at a given height.

Calculation of log volumes:

The log is first cut into smaller segments and the volume of each segment is calculated and summed. The segment length used is 10 cm.

The "I" subscript in the following formulas refers to a segment's attribute.

$$Vl = \sum_{i=1}^{n} Vs_i$$ Volume of the Log

$$Vs_i = \frac{Ab_i + At_i}{2} \times Ls$$ Volume of a segment, using *Smalian's Formula*

$$Ls = \frac{L}{n}$$ Segment Length

$$A = \frac{D^2 \times \pi}{4}$$ Cross section Area

Where:

Vl = Log Volume

Vs = Volume of a Segment

Ab = Area of the Segment's Bottom

At = Area of the Segment's Top

Am = Area of the Segment's Middle

Ls = Segment Length

L = Log Length

n = Number of Segments in a Log

D^2 = Diameter squared

A = Cross section area

Last log logic:

If the compiled last log in a tree is shorter than the minimum length allowable for the species and grade assigned, then the last log is combined with the second to last log and assigned the second to last log's grade. When the second to last log grade is N and the last log is shorter than 3.0 meters, the last log will be assigned grade Z. When the second to last log grade is N or Z and the last log is 3.0 to 4.9 m, the last log will be assigned grade Y. The log lengths are summed and the net factors are combined and weighted by length. See Appendix 1, step 2.3 and 2.4.

Damage Reports 4

The appraisal and harvest method reports will summarize blowdown, fire and insect independently. For example, if all trees had all three damage type codes recorded, the harvest method report would summarize 100% damage for all three damage types.

4.1 Damage Inputs

These are the current damage codes available for the coastal CGNF.

Damage Type	Code	Description	Species
Blowdown	E	Down trees	All Species
	G	Down trees	All Species
Fire	A	Light fire	All Species
	B	Medium fire	All Species
	C	Heavy fire	All Species
Insect/Disease	1	Green attack	Balsam, Pine
	2	Red attack	Balsam, Pine
	3	Grey attack	Balsam, Pine
	4	Blister rust	White Pine
	5	Green attack - alive	Spruce, Douglas Fir
	6	Green attack - dead	Spruce, Douglas Fir
	7	Grey attack - dead	Spruce, Douglas Fir
	8	Red attack	Douglas Fir
	X	Defoliator G live cambium	All Species
	Y	Defoliator D dead cambium	All Species
Root Rot	J	Light	All Species
	K	Moderate	All Species
	L	Heavy	All Species

4.2 No Risk Groups

There are no risk groups associated with CGNF and therefore, damage codes will not downgrade stems from one risk group to another as in loss factor compilations. The damage codes will be reported in the appraisal and harvest reports but with no corresponding change in their original net volumes based on the call grade and net factor records.

4.3 List of Damage Reports

The extended stand and stock table report is not required for coastal CGNF compilations.

The following damage reports are required for damage types Blowdown, Fire, and Insect:

1. 007 Stand and Stock Tables, one page for each species and damage type containing each of the damage codes for that damage type.

i	007a	Block Stand Table.
ii	007b	Block Stock Table.
iii	007c	Block Basal Area.
iv	007d	Timber Type Stand Table.
v	007e	Timber Type Stock Table.
vi	007f	Timber Type Basal Area.
vii	007g	Cutting Permit Stand Table.
viii	007h	Cutting Permit Stock Table.
ix	007i	Cutting Permit Basal Area.

2. 009 Volume Summaries, one page for each species and damage type reporting each of the damage codes for that damage type.

i	009a	Timber Type Summary.
ii	009b	Block Summary.
iii	009c	Cutting Permit Summary.
iv	009d	Treatment Unit within Block Summary – Coast only.

3. 011 Plot Summary, damage code volumes segregated for each species.

4. 015 Harvesting Method Summary, percent net volumes will be segregated for each Harvesting Method under the heading Fire, Heavy Fire (Damage code C), Down trees, and Insect damage.

5. 016 Appraisal Summary.

The following damage reports are optional:

1. 009b Root Rot Block Summary.

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Reduction Compilations 5

5.1 Reduction Compilations - Overview

Unless specified in this manual, follow the procedures in Chapter 5 of the Cruise Compilation Manual.

The FS 221 form allows for a reduction of the volumes and stem counts by several methods:

By species, timber type, dead/live, mature/second growth and treatment unit. Any combination of these fields can be used to apply a reduction. Treatment Unit is a mandatory field.

Please note that there are no risk groups (A-D) and no tree classes (1-9) for CGNF percent reduction compilations. Both dead/live (D/L) tree codes and mature/second growth (M/S) tree codes may be used.

For each tree, determine whether there is an eligible reduction:

1. If a Timber Type is coded, then the reduction applies to trees in that Type.

2. If the Timber Type is blank, then the reduction applies to all types.

3. If Damage is coded B, F or I on the reduction card, then do not apply the reduction to trees that have been assigned a damage code of that type.

4. If Species is non-blank, then an exact species match has to apply for the tree to be eligible for reduction. Otherwise, if Species is blank, apply the reduction to all species.

5. If the Dead/Live tree code is “D” then all dead trees will be eligible for reduction. If the Dead/Live tree code is “L” then all live trees will be eligible for reduction. Otherwise, if Dead/Live tree code is blank, apply the reduction to all dead and live trees.

6. If the Mature/Second Growth tree code is “M” then all mature trees will be eligible for reduction. If the Mature/Second Growth tree code is “S” then all second growth trees will be eligible for reduction. Otherwise, if Mature/Second Growth tree code is blank, apply the reduction to all Mature/Second Growth trees.

When a tree is targeted for a reduction, then reduce the calculated volume by the percent value that is coded for the DBH class that the tree falls into. See Section 5.3 for example.

If the DBH class is blank, then do not apply a reduction for that tree.

5.2 Percent Reduction Card Edits

5.2.1 Table of Data Types

Column Position	Column Name	Accepted Values	Error Type
1-2	Species	Blank or valid species code (Refer to Appendix 3 for valid species codes)	F
3-4	Timber Type	Blank, 99	F
5	Risk Group/Tree Class	Blank (Not used for CGNF compilations)	F
6-7	Treatment Unit	A - CU, 1-99	F
8-10	Block	Blank (not used)	F
11	Damage type	Blank, B, F, I	F
12	Mature/Second Growth tree code	Blank, M, S	F
13	Live/Dead tree code	Blank, L, D	F
14-15, 16-17, 80-81	Reduction percent for DBH class	Blank, 001 – 100	F

5.2.2 Fatal Errors

1. A tree can only qualify for one reduction.

2. Timber Type must be a valid Type from a card type C.

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Appendices

Appendix 1 Full CGNF Tree – Step by Step Example

This appendix will demonstrate how to calculate the volume for a tree using Kozak's taper equation, and will provide the associated regression coefficients and inflexion points. The volume is calculated for three sections of the tree. Section 1 is the stump, section two is the merchantable volume, and section 3 is the top of the tree. Hence, by applying these steps, both the total biological volume and the merchantable volume are calculated.

The merchantable portion of the tree is between the stump height and the height where the merchantability requirement top diameter is achieved. This portion is divided into logs based on the cruiser's selection of preferred lengths up to the merchantable top.

The last merchantable log is generally shorter than the other logs. If the last log is less than the minimum allowable length for the grade of the log, then its length and volume is added to the second to last log. The grade of the last log will take on the grade of the second to last log and the net factors are combined and weighted based on the log lengths.

There are two equations that must be used in order to determine the volume of the tree. The first is the taper equation, used to determine the diameter inside bark at a specified height above the ground. The second equation calculates the volume of a log given an upper and lower height above the ground, with associated diameters.

Taper Equation

$$d_i = a_1 D^{a_2} a_3^{D} X^{exp}$$

Where:

d_i = diameter inside bark in cm at height h_i from the ground

exp = $a_4 z^2 + a_5 \ln(z + 0.001) + a_6 \sqrt{z} + a_7(D/H) + a_8 e^z$

D = diameter at breast height in cm

X = $(1 - \sqrt{h_i / H}) / (1 - \sqrt{p})$

H = total height of tree in meters

h_i = height from ground in meters

z = h_i/H

p = inflection point, see the end of this Appendix

$a_1 \ldots a_8$ = regression coefficients, see the end of this Appendix

ln = natural logarithm

e = 2.718281828

Volume Calculation

The CGNF compiler uses Smalian's formula for calculating log volumes. To derive a tree's merchantable volume, calculate and accumulate each individual log's volume.

Calculation of Log Volumes

The log is first cut into smaller segments and the volume of each segment is calculated and summed. The segment length used is 10 cm.

The "*i*" subscript in the following formulas refers to a segment's attribute.

$$Vl = \sum_{i=1}^{n} Vs_i$$ Volume of the Log in m^3

$$Vs_i = \frac{Ab_i + At_i}{2} \times Ls$$ Volume of a segment, using Smalian's Formula in m^3

$$Ls = \frac{L}{n}$$ Segment Length in m

$$A = \frac{D^2 \times \pi}{4}$$ Cross section Area in m^2

Where:

Vl = Log Volume (m^3)

Vs = Volume of a Segment (m^3)

Ab = Area of the Segment's Top (m^2)

Ls = Segment Length (m)

L = Log Length (m)

n = Number of Segments in a Log

D^2 = Diameter squared (m)

A = Cross section area (m^2)

Last Log Logic:

If the last log in a tree is shorter than the minimum for the species and grade assigned, then the last log is combined with the second to last log and assigned the second to last log's grade. The log lengths are combined, the net factors are combined and weighted by the log's length. See Appendix 1, step 2.3 and 2.4.

Steps for Calculating the Volume of a Tree

An example of the volume calculations for a single tree is given. Please refer to Appendix 2 for log grade validations, Appendix 3 for CGNF breakage tables, and Appendix 4 for net volume adjustment factors.

Example #1:

The tree parameters are:

Species:	**Cypress**
DBH:	110.0 cm
Total Height:	41.0 m
F.I.Z.	C
Stump Height:	30 cm
Top Diameter:	15.0 cm
Maturity:	Mature
Live/Dead:	Live

The log parameters are (as recorded by the cruiser):

Log #	Grade	Log len (m)	Net factor (%)
1	Z	1	100
2	D	8	100
3	H	13	90
4	U	11	93
5	X	99*	70

* A “99” log length instructs the compiler program to extend the length of the last log up to the merch height of the tree (to the utilization limit).

Step 1 Look up the appropriate regression coefficients, a_1, a_2,, a_8 and the inflection point, p. These parameters are dependent on species and Forest Inventory Zone. They are provided in the tables in the back of this Appendix.

Cypress taper parameters for FIZs A, B andC are:

p = 0.30

a_1 = 0.928138

a_2 = 0.945293

a_3 = 0.999206

a_4 = 0.301423

a_5 = -0.040792

a_6 = -1.235630

a_7 = 0.030743

a_8 = 0.672879

Step 2 Determine the biological and gross merchantable volume.

2.1 Calculate the diameter inside bark at stump height using the taper equation. Substitute the stump height for h_i (if the resultant diameter is less than the specified top diameter, return 0 volume).

Solve the taper equation using 0.3 m as hi (only 9 decimal places are shown).

$X = (1 - \sqrt{0.3/41.0}) / (1 - \sqrt{0.3})$

$= (0.914460107\ldots) / (0.452277442)$

$= 2.021900767$

$Exp = a_4 z^2 + a_5 \ln(z + 0.001) + a_6 \sqrt{z} + a_7(D/H) + a_8 e^z$

$= 0.301423(0.30 / 41.0)^2 - 0.040792\ln((0.30 / 41.0) + 0.001)$

$- 1.235630\sqrt{0.3/41} + 0.030743(110.0 / 41.0)$

$+ 0.672879(2.718281828)^{0.30/41.0}$

$= 0.84999330$

$d_{30} = (0.928138(110.0)^{0.945293})(0.999206)^{110.0}(2.02190)^{0.84999330}$

$= 131.61$ cm

2.2 Calculate the merchantable height of the tree.

There are many ways to find the solution for the merchantable height. However, all methods use a binary search to iterate the proportion of the height at which merch height occurs. This method starts by substituting 0.9 (proportion of the total height to estimate the merch height) into the 'z_0' variable in the exp equation calculated in step 2.1 above. Once the exp variable is calculated, it is substituted into the taper equation for (hi/H). This provides a new estimate of the proportion hi/H at the merch ht. The first estimated proportion is compared to the new estimated proportion. When the two proportions are less than 0.00001 different, then the iteration ends. This proportion is multiplied by the total height of the tree to obtain the merchantable height.

a. Start $hi/H = z_0 = 0.9$

Substitute 0.9 into the formula:

$Exp = a_4 z_0^2 + a_5 \ln(z_0 + 0.001) + a_6 \sqrt{z0} + a_7(D/H) + a_8 e^{z0}$

$= 0.301423(0.9)^2 - 0.040792\ln((0.9) + 0.001)$

$- 1.235630\sqrt{0.9} + 0.030743(110.0 / 41.0)$

$+ 0.672879(2.718281828)^{0.9}$

$= 0.81368015$

b. Substitute exp into the taper formula and solve for proportion hi/H = z_1

$z_1 = [1 - ((d_i / (a_1 * D^{a2} * a3^D)) (^{1 / exp})) * (1 - \sqrt{p}\,)]^2$

$= [1 - ((15 / (0.928138 * (110.0)^{0.945293} *$

$0.999206^{110.0}))^{1/0.81368015})) * (1 - \sqrt{0.3}\,)]^2$

$= 0.87345586$

c. Compare results of z_0 with z_1. Subtract one proportion from the other. If the result is < 0.00001 and number of iterations is < 10,000 then stop the iteration.

$= 0.9 - 0.87345586$

$= 0.026544$

d. Since the result of the test was > 0.00001, therefore, continue iteration by halving the estimate of the proportion until result is < 0.00001.

New $z_0 = (z_0 + z_1)/2$

$= (0.9 + 0.87345586) / 2$

$= 0.88672793$

e. Continue back to step 2.2.a until the test results in < 0.00001.

Here are the results of the iteration until a solution was found:

exp	z0	z1	z0-z1 (<0.00001)
0.813680155	0.9	0.87345587	0.026544
0.793992663	0.886727934	0.87918892	0.007539
0.788486514	0.882958425	0.88079644	0.002162
0.786914461	0.881877432	0.88125569	0.000622
0.786462942	0.881566559	0.88138761	0.000179
0.786333036	0.881477085	0.88142557	0.000052
0.786295642	0.881451327	0.88143650	0.000015
0.786284877	**0.881443912**	**0.88143964**	**0.000004**

z0-z1 = 0.881443912 – 0.88143964 = 0.000004 < 0.00001

Therefore, the iteration can stop.

f. Solve for merchantable height.

Merchantable height = last z0 * Total height

= 0.881443912 * 41.0

= 36.139 m

= 36.1 m

2.3 Calculate the length of the last log. Use this calculation even when a cruiser calls a length for the top log instead of 99.

Last log = merch. Height – (sum of log lengths) – stump height.

Last log = 36.14 - (1+8+13+11) - 0.30

= 3.14 - 0.30

= 2.84 m for last log of grade X

If the last log is less than the minimum log length for the species and grade, then append it to the second to last log.

For this example, since the last log is shorter than the minimum log length of 5.0m for X grade Yellow Cedar, the last log must be combined with the second to last log.

The last log now becomes 13.84m of U grade. There are now only 4 merchantable logs for this tree. Note: The remainder of the example will use only 4 logs in the calculations.

2.4 Calculate the new net factor for the last log ONLY if the last log is combined with the second to last log.

The log parameters are:

Log #	Grade	Log len (m)	Net factor (%)
1	Z	1	100
2	D	8	100
3	H	13	90
4	U	11	93
5	X	2.84	70

To calculate a new net factor for log # 4, simply weight the net factor of log # 4 and log # 5 by the log length of each and combine.

New Net Factor for log 4 = log 4 NF * log 4 len/ sum (log 4&5) +

log 5 NF * log 5 len/sum (log 4&5

= 93%*(11/13.84) + 70%*(2.84/13.84)

NF log 4 = 88.3%

Log #	Grade	Log len (m)	Net factor (%)
1	Z	1	100
2	D	8	100
3	H	13	90
4	U	13.84	88.3
5	Combined with log 4		

2.5 Calculate the top diameter of each merchantable log using the taper equation.

Consider a tree with four merchantable logs, with the following top heights and top diameters. See Step 2.1 above, for example of top diameter calculation.

Log #	Grade	Log len (m)	Top Diameter
1	Z	1	109.69
2	D	8	76.87
3	H	13	56.81
4	U	13.84	15.00
5	Combined with log 4		

2.6 Calculate the volume of the log using Smalian's volume equation, using 10cm segments.

Gross Merch volume of a Single Log - Use the taper equation to determine the 10 diameters for log # 1- grade Z, 1m length.

Position	h_i	d_i - taper equation	Area (m^2)	Gross Volume (m^3)
stump	0.3 m	131.60 cm	1.3603	-
1	0.4 m	127.75 cm	1.2817	0.1321
2	0.5 m	124.60 cm	1.2193	0.1250
3	0.6 m	121.92 cm	1.1674	0.1193
4	0.7 m	119.59 cm	1.1232	0.1145
5	0.8 m	117.52 cm	1.0848	0.1104
6	0.9 m	115.67 cm	1.0508	0.1068
7	1.0 m	113.98 cm	1.0204	0.1036
8	1.1 m	112.44 cm	0.9929	0.1007
9	1.2 m	111.01 cm	0.9679	0.0980
10	1.3 m	109.69 cm	0.9450	0.0956

Volume of Log # 1: sum each 10cm segment of the log for volume.

Vol Log $_1$ = Section 1 length * (Area (stump dia) + Area section 1) / 2 +

Section 2 length * (Area (section 1 dia) + Area section 2) / 2 +

Section 3 length * (Area (section 2 dia) + Area section 3) / 2 +

Section 4 length * (Area (section 3 dia) + Area section 4) / 2 +

Section 5 length * (Area (section 4 dia) + Area section 5) / 2 +

Section 6 length * (Area (section 5 dia) + Area section 6) / 2 +

Section 7 length * (Area (section 6 dia) + Area section 7) / 2 +

Section 8 length * (Area (section 7 dia) + Area section 8) / 2 +

Section 9 length * (Area (section 8 dia) + Area section 9) / 2 +

Section 10 length * (Area (section 9 dia) + Area section 10) / 2

Vol Log $_1$ = 0.1 * (1.3603 + 1.2817) / 2 +

0.1 * (1.2817 + 1.2193) / 2 +

0.1 * (1.2193 + 1.1674) / 2 +

0.1 * (1.1674 + 1.1232) / 2 +

0.1 * (1.1232 + 1.0848) / 2 +

0.1 * (1.0848 + 1.0508) / 2 +

0.1 * (1.0508 + 1.0204) / 2 +

0.1 * (1.0204 + 0.9929) / 2 +

0.1 * (0.9929 + 0.9679) / 2 +

0.1 * (0.9679 + 0.9450 / 2

Vol Log 1 = 1.1061 m3

Summary of volume by log:

Log Position	Grade	Length (m)	hi (m)	Butt Dia (cm)	Top Dia (cm)	Gross Volume (m^3)
1	Z	1	1.3	131.61	109.69	1.1061
2	D	8	9.3	109.69	76.87	4.9096
3	H	13	22.3	76.87	56.81	4.6556
4	U	13.84	36.14	56.81	15.00	1.7283
Gross Merch Vol						12.4000

2.7a Calculate the biological volume. Calculate the stump volume and top volumes and then sum with the gross merchantable volume.

If the stump height <= 30 cm, then:

$$\frac{\text{Stump volume}}{(30\text{cm \& below})} = C * d_{30}^{2} * (\text{stump height})$$

Where C = 0.00007854

d_{30} = diameter at 30 cm

Stump volume = $(0.00007854)*(0.30)*(131.60)^2 = 0.4081\ m^3$

If the stump height is greater than 30 cm, then calculate the stump volume below 30 cm as shown above. Then, apply the appropriate log volume equation using the lower bound parameters (30 cm, d_{30}) and the upper bound parameters (stump height, diameter at stump height).

2.7b Calculate the top volume

Apply the same log volume equation as used in the merchantable log calculation. The lower parameters of merch. height and top diameter of 15cm and the upper bound parameters of total height and 0.0cm would be used. The section length would continue in 10cm segments until the top of the tree was reached.

The top log length is 41.0 - 36.14 = 4.86 m. The total volume of the tip would be 0.0266 m3.

Step 3 Determine the biological and gross merchantable volume.

Apply net downs. Cruiser estimated net factors by log for decay volume, cruiser called Z grades for waste volume, CGNF lookup table for breakage volume, and NVAF corrections from CGNF process.

For a list of the terms used in the following calculations see *Chapter 3, step 3*.

For the net down example, log # 3 will be used:

H grade, NF = 90%, Gross vol = 4.6556m3.

3.1 For each log, calculate the log breakage volume. Use the CGNF breakage % table by species, and maturity. The NVAF process did not include breakage volume, therefore, the breakage volume must be taken out before the remainder of the volume is adjusted. See

Appendix 3 for the CGNF breakage table.

$B_i = V_i \times Fb$

Breakage volume = 4.6556 * 7% = 0.3259 m^3

Calculate log gross volume minus breakage.

$VmB_i = V_i(1 - Fb)$

The breakage factor for Yellow Cedar is 7%.

Gross volume minus breakage = Gross volume * (1-7%)

= 4.6556 * (93%)

= 4.3297 m^3

3.3 Apply the taper correction factor. The taper correction is used to correct the known bias in the gross volume of taper equations. These factors are corrected by species, maturity and live/dead. See *Appendix 4* for the NVAF adjustment table.

$VmBc_i = VmB_i \times Ft$

The taper adjustment factor for live Yellow Cedar is: 1.050

Gross Volume minus breakage after taper correction

= Gross volume minus breakage * taper correction factor.

= 4.3297 m^3 * 1.050

= 4.5462 m^3

3.4 Calculate the corrected gross volume.

$Vc_i = VmBc_i + B_i$

Gross volume after correction

= Gross Volume minus breakage after taper correction + breakage volume

= 4.5462 m^3 + 0.3259 m^3

= 4.8720 m^3

3.5 Calculate the tree decay factor. Take the average of all the log's net factors weighted by the sum of each log's gross volume minus breakage after taper correction calculated in step 3.3 above.

$$Fd = \frac{\sum_{i=1}^{n} (Fd_i \times VmBc_i)}{\sum_{i=1}^{n} VmBc_i}$$

= (100%*1.0801)+(100%*4.7943)+(90%*4.5462)+(88.3%*1.6876)/ 12.1082 m^3

= 11.45613 m^3 / 12.1082 m^3

= 94.6%

3.6 Correct the tree decay factor using the NVAF coefficients

$$Fdc = Fr \times Fd^{Fp}$$

Fr = NVAF correction ratio = 0.954 for live Yellow Cedar

Fp = NVAF correction power = 1.270 for live Yellow Cedar

NVAF corrections are found in *Appendix 4.*

NVAF corrected Net factor

= NVAF correction ratio * tree decay factor$^{\text{NVAR correction}}$

= 0.954 * 94.6% $^{1.270}$

= 88.9%

3.7 Calculate the adjusted decay factor by the NVAF factor. This is the net corrected volume for all logs except Z grade logs. For Z grade logs, the $VmBDc_i$ is the waste volume.

$$VmBDc_i = VmBc_i \times Fd_i \times \frac{Fdc}{Fd}$$

Gross vol corrected minus breakage and decay volume =

Gross vol corrected minus breakage volume * NF%log3 * correction

Decay factor/ cruiser's estimate of net %

= 4.5462 m^3 * 90% * 88.9% / 94.6%

= 3.8454 m^3 –

3.8 Calculate the decay volume

$$D_i = VmBc_i \times (1 - (Fd_i \times \frac{Fdc}{Fd}))$$

Decay corrected volume = Gross vol corrected minus breakage vol *

(1- (NF% log3 * corr Decay factor / cruiser's estimate of net %))

= 4.5462 m3 * (1 – (90% * 88.9%/ 94.6%)

= 4.5462 m3 * (0.1542)

= 0.7008 m^3

Note: Data as presented has been rounded for summary purposes. The final value is calculated based on the full intermediate significant figures (see Appendix 16 of the *Cruise Compilation Manual*).

3.9 Calculate the waste volume. (Only logs in the tree with "Z" grade)

$Vw_i = VmBDc_i$

$Vn_i = 0$

otherwise:

$Vw_i = 0$

$Vn_i = VmBDc_i$

If the log is a Z grade, the VmBDc = waste volume.

If the log is any grade except N or Z then the VmBDc = net volume. Note that N contributes to the decay/missing wood volume and Z contributes to the waste component.

3.10 Calculate the net volume. (Gross volume corrected – DWB volumes)

$$Vn = \sum_{i=1}^{n} Vn_i$$

Note – the volumes in these tables are are summed for all trees and reported as a percentage of the total volume by species, coniferous and all species.

Log Position	Grade	Length (m)	Gross Volume (m^3)	Gross Volume Corr. (m^3)	Decay Volume Corr. (m^3)	Waste Volume Corr. (m^3)	Breakage Volume Uncorr. (m^3)	Net Volume Corr. (m^3)
1	Z	1	1.1061	1.1575	0.0650	1.0151	0.0774	0.0000
2	D	8	4.9096	5.1379	0.2884		0.3437	4.5058
3	H	13	4.6556	4.8720	0.7008		0.3259	3.8454
4	U	13.84	1.7283	1.8086	0.2874		0.1210	1.4002
Totals		35.84	12.3996	12.9761	1.3416	1.0151	0.8680	9.7515

Example 2: Specifically designed for trees that contain N grade logs (missing sections in a tree).

The tree parameters are:

Species:	**Douglas-fir**
DBH:	89.6 cm
Total height:	36.9 m
F.I.Z.	C
Stump height:	30 cm
Top diameter:	15.0 cm
Maturity:	Mature
Live/Dead:	Dead

The log parameters are (as recorded by the cruiser):

Log #	Grade	Log Length (m)	Net Factor (%)
1	N*	1	00
2	H	8	95
3	I	7	98
4	N*	3	00
5	U	11	89
6	N*	99**	00

* an N grade indicates that the log is missing and therefore, no volume is present. The N grade can be any log length as shown in this example.

** a 99 log length instructs the compiler program to extend the length of the last log up to the merch height of the tree (to the utilization limit).

Douglas-fir taper parameters for FIZs A, B and C are:

Step 1 Look up the appropriate regression coefficients, a_1, a_2,, a_8 and the inflection point, p. These parameters are dependent on species and Forest Inventory Zone. They are provided in the tables in the back of this Appendix.

p = 0.25

a_1 = 1.012675

a_2 = 0.899136

a_3 = 1.000123

a_4 = 0.968978

a_5 = -0.190913

a_6 = 0.825961

a_7 = 0.048766

a_8 = -0.426214

Step 2 Determine the biological and gross merchantable volume.

2.1 Calculate the diameter inside bark at stump height using the Taper equation. Substitute the stump height for h_i (if the resultant diameter is less than the specified top diameter, return 0 volume).

d_{30} = 86.54 cm

2.2 Calculate the merchantable height of the tree.

Merchantable height = 32.57m

2.3 Calculate the length of the last log. Use this calculation even when a cruiser calls a length for the top log instead of 99.

Last log = merch. Height – (sum of log lengths) – stump height

Last log

= 32.57 - (8+1+7+3+11) - 0.30

= 2.57 - 0.30

= 2.27 m for last log of grade N

If the last log is less than the minimum log length for the species and grade, then append it to the second to last log.

For this example, since the last log is longer than the minimum log length of 0.0m for N grade Douglas-fir, the last log remains the last log.

There remains 6 merchantable logs for this tree.

2.4 Calculate the new net factor for the last log ONLY if the last log is combined with the second to last log.

Since the last logs remains as the last log, this step is not required.

2.5 Calculate the top diameter of each merchantable log using the taper equation.

Log #	Grade	Log len (m)	Top Diameter
1	N	1	73.11
2	H	8	58.22
3	I	7	50.71
4	N	1	46.42
5	U	11	21.77
6	N	2.27	15.00

2.6 Calculate the volume of the log using Smalian's volume equation, using 10cm segments.

Gross Merch volume of a Single Log - Use the taper equation to

determine the 10 diameters for log # 1- grade N, 1m length.

Position	h_i	d_i - taper equation	Area (m^2)	Gross Volume (m^3)
stump	0.3 m	86.54 cm	0.5881	-
1	0.4 m	83.72 cm	0.5505	0.0569
2	0.5 m	81.59 cm	0.5228	0.0537
3	0.6 m	79.88 cm	0.5012	0.0512
4	0.7 m	78.47 cm	0.4836	0.0492
5	0.8 m	77.27 cm	0.4689	0.0476
6	0.9 m	76.23 cm	0.4564	0.0463
7	1.0 m	75.32 cm	0.4456	0.0451
8	1.1 m	74.51 cm	0.4360	0.0441
9	1.2 m	73.77 cm	0.4275	0.0432
10	1.3 m	73.11 cm	0.4198	0.0424

Volume of Log # 1: sum each 10cm segment of the log for volume = 0.4796 m^3.

Summary of volume by log:

Log Position	Grade	Length (m)	hi (m)	Butt Dia (cm)	Top Dia (cm)	Gross Volume (m^3)
1	N*	1	1.3	86.54	73.11	0.4796
2	H	8	9.3	73.11	58.22	2.5357
3	I	7	16.3	58.22	50.71	1.6449
4	N*	3	19.3	50.71	46.42	0.5578
5	U	11	30.3	46.42	21.77	1.1214
6	N*	2.27	32.57	21.77	15.00	0.0612
Gross Merch Vol						6.4007

* N grade logs are portions missing from the tree. CGNF procedures do not separate the procedures for calculating missing wood and decay volume. Logs with missing wood (scars, mechanical damage), catfaces with missing wood, and logs with large hollow boles are net factored. Net factoring, technically is a process that removes decay volume from the gross volume of the log. In order to be consistent with this process, N grade logs' gross merchantable volume will be reported as full gross merchantable volume. A net factor of zero will be assigned to these logs so that net volume is zero. The procedure for dealing with missing wood versus decay volume may be reviewed in the future.

2.7a Calculate the biological volume. Calculate the stump volume and top volumes and then sum with the gross merchantable volume.

Stump volume = $(0.00007854)*(0.30)*(86.54)^2 = 0.1764\ m^3$

2.7b Calculate the top volume

Apply the same log volume equation as used in the merchantable log calculation. The lower parameters of merch. height and top diameter

of 15cm and the upper bound parameters of total height and 0.0cm would be used. The section length would continue in 10cm segments until the top of the tree was reached.

The top log length is 36.9 – 32.57 = 4.33 m. The total volume of the tip would be 0.0291 m^3.

Step 3 Apply net downs. Cruiser estimated net factors by log for decay volume, cruiser called Z grades for waste volume, CGNF lookup table for breakage volume, and NVAF corrections from CGNF process.

For a list of the terms used in the following calculations see Chapter 3, step 3.

For the net down example, log # 4 will be used:

N grade, NF = 00%, Gross vol = 0.5578 m^3.

3.1 For each log, calculate the log breakage volume. Use the CGNF breakage % table by species, and maturity. The NVAF process did not include breakage volume, therefore, the breakage volume must be taken out before the remainder of the volume is adjusted. See *Appendix 3* for the CGNF breakage table.

$$B_i = V_i \times Fb$$

Breakage volume = 0.5578 * 5% = 0.0279 m^3

3.2 Calculate log gross volume minus breakage.

$$VmB_i = V_i(1 - Fb)$$

The breakage factor for Douglas-fir is 5%.

Gross volume minus breakage = Gross volume * (1-5%)

= 0.5578 * (95%)

= 0.5299 m^3

3.3 Apply the taper correction factor. The taper correction is used to correct the known bias in the gross volume of taper equations. These factors are corrected by species, maturity and live/dead. See Appendix 4 for the NVAF adjustment table.

$$VmBc_i = VmB_i \times Ft$$

The Taper adjustment factor for dead Douglas-fir is: 0.855

Gross Volume minus breakage after taper correction.

= Gross volume minus breakage * taper correction factor.

= 0.5299 m3 * 0.855

= 0.4531 m^3

3.4 Calculate the corrected gross volume.

$Vc_i = VmBc_i + B_i$

Gross volume after correction.

= Gross Volume minus breakage after taper correction + breakage volume

= 0.4531 m3 + 0.0279 m^3

= 0.4810 m^3

3.5 Calculate the tree decay factor. Take the average of all the log's net factors weighted by each log's gross volume minus breakage after taper correction calculated in step 3.3 above.

$$Fd = \frac{\sum_{i=1}^{n}(Fd_i \times VmBc_i)}{\sum_{i=1}^{n} VmBc_i}$$

(0%*0.3896)+(95%*2.0596)+(98%*1.3361)+(0%*0.4531)/ 5.1990 m^3

= 4.0767 m^3 / 5.1990 m^3

= 78.4%

3.6 Correct the tree decay factor using the NVAF coefficients.

$Fdc = Fr \times Fd^{Fp}$

Fr = NVAF correction ratio = 0.860 for dead Douglas-fir.

Fp = NVAF correction power = 1.000 for dead Douglas-fir.

NVAF corrections are found in Appendix 4.

NVAF corrected Net factor.

= NVAF correction ratio * tree decay factor$^{\text{NVAR correction}}$

= 0.860 * 78.4% $^{1.000}$

= 67.4%

3.7 Calculate the adjusted decay factor by the NVAF factor. This is the net corrected volume for all logs except Z grade logs. For Z grade logs, the $VmBDc_i$ is the waste volume.

$$VmBDc_i = VmBc_i \times Fd_i \times \frac{Fdc}{Fd}$$

Gross vol corrected minus breakage and decay volume =.

Gross vol corrected minus breakage volume * NF%log4 * corrected.

Decay factor/ cruiser's estimate of net %.

= 0.4531 m^3 * 0% * 67.4% / 78.4%.

= 0.0000 m^3

3.8 Calculate the decay volume:

$$D_i = VmBc_i \times (1 - (Fd_i \times \frac{Fdc}{Fd}))$$

Decay corrected volume = Gross vol corrected minus brk vol *

(1- (NF% log4 * corr Decay factor / cruiser's estimate of net %))

= 0.4531 m^3 * (1 – (0% * 67.4%/ 78.4%**)**

= 0.4531 m^3 * (1.0000)

= 0.4531 m^3

Note: Data has been rounded for summary purposes. The final value is calculated based on intermediate significant figures (see Appendix 16 of the *Cruise Compilation Manual*).

3.9 Calculate the waste volume. (Only logs in the tree with "Z" grade).

Since log 4 is an N grade, there is no waste volume from log 4.

$Vw_i = VmBDc_i$

$Vn_i = 0$

otherwise:

$Vw_i = 0$

$Vn_i = VmBDc_i$

If the log is a Z grade, the VmBDc = waste volume.

If the log is any other grade, except N then the VmBDc = net volume.

3.10 Calculate the net volume (gross volume corrected – DWB volumes).

$$Vn = \sum_{i=1}^{n} Vn_i$$

Log Position	Grade	Length (m)	Gross Volume (m^3)	Gross Volume Corr. (m^3)	Decay Volume Corr. (m^3)	Waste Volume Corr. (m^3)	Breakage Volume Uncorr. (m^3)	Net Volume Corr. (m^3)
1	N	1	0.4796	0.4136	0.3896		0.0240	0.0000
2	H	8	2.5357	2.1864	0.3789		0.1268	1.6827
3	I	7	1.6449	1.4183	0.2100		0.0822	1.1260
4	N	3	0.5578	0.4180	0.4531		0.0279	0.0000
5	U	11	1.1214	0.9669	0.2137		0.0561	0.6972
6	N	2.27	0.0612	0.0528	0.0497		0.0031	0.0000
Totals		32.27	6.4007	5.4560	1.6950		0.3201	3.5059

Appendix 2 Log Grade Validations

Please see Section 2.2.3 for examples of errors and warnings associated with the tables in Appendix 2.

Douglas-fir (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
F	B	5	60	9999	80
F	C	5	38	9999	80
F	D	5	76	9999	75
F	F	5	60	9999	75
F	H	5	38	50	75
F	H	5	50	9999	50
F	I	5	38	50	75
F	I	5	50	9999	50
F	J	5	15	38	75
F	U	5	38	9999	50
F	U	5	15	38	67
F	U	5	10	15	75
F	X	5	10	9999	33
F	Y	3	10	9999	10
F	N	1	10	9999	0
F	Z	1	10	9999	0

Cedar (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
C	D	5	60	120	75
C	D	5	120	9999	67
C	F	5	50	9999	75
C	H	5	38	9999	75
C	I	5	38	50	75
C	I	10	50	9999	50
C	K	4	50	9999	50
C	L	4	38	9999	50
C	M	4	38	9999	50
C	J	5	15	38	75
C	U	5	38	9999	50
C	U	5	15	38	67
C	U	5	10	15	75
C	X	5	10	9999	33
C	Y	3	10	9999	10
C	N	1	10	9999	0
C	Z	1	10	9999	0

Hemlock (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
H	D	5	66	9999	75
H	F	5	50	9999	75
H	H	5	38	9999	75
H	I	5	38	9999	50
H	J	5	15	38	75
H	U	5	38	9999	50
H	U	5	15	38	67
H	U	5	10	15	75
H	X	5	10	9999	33
H	Y	3	10	9999	10
H	N	1	10	9999	0
H	Z	1	10	9999	0

Balsam (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
B	D	5	66	9999	75
B	F	5	50	9999	75
B	H	5	38	9999	75
B	I	5	38	9999	50
B	J	5	15	38	75
B	U	5	38	9999	50
B	U	5	15	38	67
B	U	5	10	15	75
B	X	5	10	9999	33
B	Y	3	10	9999	10
B	N	1	10	9999	0
B	Z	1	10	9999	0

Spruce (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
S	F	5	76	9999	75
S	G	5	60	9999	75
S	H	5	38	9999	75
S	H	5	60	50	50
S	I	5	38	50	75
S	I	5	50	9999	50
S	J	5	15	38	75
S	U	5	38	9999	50
S	U	5	15	38	67
S	U	5	10	15	75
S	X	5	10	9999	33
S	Y	3	10	9999	10
S	N	1	10	9999	0
S	Z	1	10	9999	0

Cypress (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
CY	D	5	60	9999	75
CY	F	5	50	9999	75
CY	H	5	38	9999	50
CY	I	5	38	9999	50
CY	J	5	15	38	75
CY	U	5	38	9999	50
CY	U	5	15	38	67
CY	U	5	10	15	75
CY	X	5	10	9999	33
CY	Y	3	10	9999	10
CY	N	1	10	9999	0
CY	Z	1	10	9999	0

White Pine (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
PW	D	5	76	9999	75
PW	F	5	60	9999	75
PW	H	5	38	9999	75
PW	H	5	50	9999	50
PW	I	5	38	50	75
PW	I	5	50	9999	50
PW	J	5	15	38	75
PW	U	5	38	9999	50
PW	U	5	15	38	67
PW	U	5	10	15	75
PW	X	5	10	9999	33
PW	Y	3	10	9999	10
PW	N	1	10	9999	0
PW	Z	1	10	9999	0

Lodgepole Pine (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
PL	D	5	76	9999	75
PL	F	5	60	9999	75
PL	H	5	38	50	75
PL	H	5	50	9999	50
PL	I	5	38	50	75
PL	I	5	50	9999	50
PL	J	5	15	38	75
PL	U	5	38	9999	50
PL	U	5	15	38	67
PL	U	5	10	15	75
PL	X	5	10	9999	33
PL	Y	3	10	9999	10
PL	N	1	10	9999	0
PL	Z	1	10	9999	0

Ponderosa Pine (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
PY	D	5	76	9999	75
PY	F	5	60	9999	75
PY	H	5	38	50	75
PY	H	5	50	9999	50
PY	I	5	38	50	75
PY	I	5	50	9999	50
PY	J	5	15	38	75
PY	U	5	38	9999	50
PY	U	5	15	38	67
PY	U	5	10	15	75
PY	X	5	10	9999	33
PY	Y	3	10	9999	10
PY	N	1	10	9999	0
PY	Z	1	10	9999	0

Larch (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
L	D	5	76	9999	75
L	F	5	60	9999	75
L	H	5	38	50	75
L	H	5	50	9999	50
L	I	5	38	50	75
L	I	5	50	9999	50
L	J	5	15	38	75
L	U	5	38	9999	50
L	U	5	15	38	67
L	U	5	10	15	75
L	X	5	10	9999	33
L	Y	3	10	9999	10
L	N	1	10	9999	0
L	Z	1	10	9999	0

Cottonwood (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
AC	C	5	25	9999	80
AC	I	5	25	9999	50
AC	U	5	25	9999	50
AC	U	5	15	25	67
AC	U	5	10	15	75
AC	Y	3	10	9999	10
AC	N	1	10	9999	0
AC	Z	1	10	9999	0

Alder (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
D	I	5	25	9999	50
D	U	5	25	9999	50
D	U	5	15	25	67
D	U	5	10	15	75
D	Y	3	10	9999	10
D	N	1	10	9999	0
D	Z	1	10	9999	0

Maple (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
MB	I	5	25	9999	50
MB	U	5	25	9999	50
MB	U	5	15	25	67
MB	U	5	10	15	75
MB	Y	3	10	9999	10
MB	N	1	10	9999	0
MB	Z	1	10	9999	0

Birch (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
E	I	5	25	9999	50
E	U	5	25	9999	50
E	U	5	15	25	67
E	U	5	10	15	75
E	Y	3	10	9999	10
E	N	1	10	9999	0
E	Z	1	10	9999	0

Aspen (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
AT	I	5	25	9999	50
AT	U	5	25	9999	50
AT	U	5	15	25	67
AT	U	5	10	15	75
AT	Y	3	10	9999	10
AT	N	1	10	9999	0
AT	Z	1	10	9999	0

Whitebark Pine (except heli-log = 4m):

Species	Grade	Min Log Len (m)	Min Top Dia (cm)	Max Top Dia (cm)	Min Net Factor (%)
PA	D	5	76	9999	75
PA	F	5	60	9999	75
PA	H	5	38	50	75
PA	H	5	50	9999	50
PA	I	5	38	50	75
PA	I	5	50	9999	50
PA	J	5	15	38	75
PA	U	5	38	9999	50
PA	U	5	15	38	67
PA	U	5	10	15	75
PA	X	3	10	9999	33
PA	Y	3	10	9999	10
PA	N	1	10	9999	0
PA	Z	1	10	9999	0

Appendix 3 CGNF Breakage Table

These breakage factors are to be used for CGNF compilations only.

Species	Maturity	%
All conifers	Second Growth	2%
All deciduous	Second Growth	4%
Pl, Py	Mature	2%
L	Mature	4%
F, S, Pw, Pa	Mature	5%
H, B	Mature	5.5%
Cw, Yc	Mature	7%
All deciduous	Mature	5%

Appendix 4 Net Volume Adjustment factors (NVAF)

Species	Live/Dead	Age Class	Taper Ratio	NVAF Ratio	NVAF Power
F	D	ALL	0.855	0.86	1
F	L	2nd Growth	1.006	1	1
F	L	MAT	0.964	0.976	1.296
C	D	ALL	0.998	0.956	1
C	L	2nd Growth	0.998	0.981	1
C	L	MAT	1.078	0.994	1.085
HW	D	ALL	0.855	0.86	1
HW	L	2nd Growth	1.019	0.998	1
HW	L	MAT	0.988	0.947	0.844
B	D	ALL	0.855	0.86	1
B	L	2nd Growth	0.967	1	1
B	L	MAT	0.998	0.93	1
S	D	ALL	0.855	0.86	1
S	L	2nd Growth	1.015	0.997	1
S	L	MAT	1	1	1
CY	D	ALL	0.998	0.956	1
CY	L	ALL	1.05	0.954	1.27
PW	D	ALL	0.855	0.86	1
PW	L	ALL	1	1	1
PL	D	ALL	0.855	0.86	1
PL	L	ALL	1	1	1
PY	D	ALL	0.855	0.86	1

Species	Live/Dead	Age Class	Taper Ratio	NVAF Ratio	NVAF Power
PY	L	ALL	1	1	1
L	D	ALL	0.855	0.86	1
L	L	ALL	1	1	1
AC	D	ALL	0.855	0.86	1
AC	L	ALL	1	1	1
D	D	ALL	0.855	0.86	1
D	L	ALL	0.967	1	1
MB	D	ALL	0.855	0.86	1
MB	L	ALL	1	1	1
E	D	ALL	0.855	0.86	1
E	L	ALL	1	1	1
AT	D	ALL	0.855	0.86	1
AT	L	ALL	1	1	1
PA	D	ALL	0.855	0.86	1
PA	L	ALL	1	1	1
HM	D	ALL	0.855	0.86	1
HM	L	2^{nd} Growth	0.984	1	1
HM	L	MAT	0.9	0.945	1

Appendix 5 Spruce High Grade Table

Percentages within Spruce Grades

District	**G**	**F**
	E	D
Campbell River	**68** 32	**74** 26
Chilliwack	**100** 0	**0** 0
South Island	**94** 6	**39** 61
North Coast	**67** 33	**52** 48
North Island-Central Coast	**66** 34	**44** 56
Haida Gwaii	**66** 34	**32** 68
Squamish	**100** 0	**0** 0
Sunshine Coast	**66** 34	**49** 51

Source of the table is the Coast Grade Distribution Report *2011-04-01 to 2013-03-31.*

Example:

In the South Island District when a log is recorded as G, 94% of the log net volume will be deemed to be G grade and 6% will be deemed to be E grade. Similarly, when a log is recorded as an F grade, 39% will be F grade and 61% will be D grade.

Appendix 6 Taper Coefficients for BC Commercial Species

Inflection Points

p

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	0.25	0.25	0.25
C	0.25	0.30	0.30
H	0.20	0.25	0.25
B	0.25	0.30	0.30
S	0.25	0.30	0.30
Y	0.30	0.30	0.30
PW	0.25	0.25	0.25
PL	0.25	0.25	0.25
PY	0.25	0.25	0.25
L	0.30	0.30	0.30
AC	0.25	0.25	0.25
D	0.30	0.30	0.30
MB	0.25	0.25	0.25
E	0.25	0.25	0.25
AT	0.20	0.20	0.20
PA	0.25	0.25	0.25

Regression Coefficients

a_1

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	1.012675	0.920840	0.920840
C	1.218296	1.033575	1.033575
H	0.830874	0.752027	0.752027
B	0.988964	1.008741	0.764353
S	0.924126	0.897311	0.897595
Y	0.928138	0.928138	0.928138
PW	0.868943	0.984019	0.984019
PL	0.774601	0.774601	0.793793
PY	0.856592	0.856592	0.856592
L	0.746827	0.746827	1.164819
AC	0.802839	0.802839	0.852579
D	0.718188	0.718188	0.718188
MB	0.802839	0.802839	0.852579
E	0.648830	0.648830	0.633306
AT	0.855966	0.855966	0.891641
PA	1.078961	1.078961	1.078961

a_2

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	0.899136	0.923867	0.923867
C	0.855983	0.896971	0.896971
H	1.005210	1.028970	1.028970
B	0.951803	0.916357	1.053220
S	0.950707	0.957090	0.957499
Y	0.945293	0.945293	0.945293
PW	0.976312	0.941322	0.941322
PL	1.040320	1.040320	1.049320
PY	0.936402	0.936402	0.936402
L	1.003900	1.003900	0.831995
AC	0.993776	0.993776	0.952969
D	1.052190	1.052190	1.052190
MB	0.993776	0.993776	0.952969
E	1.121390	1.121390	1.110510
AT	0.987014	0.987014	0.957835
PA	0.894083	0.894083	0.894083

a_3

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	1.000123	1.000568	1.000568
C	0.999921	0.999079	0.999079
H	0.999142	0.998660	0.998660
B	0.999789	1.001159	0.994711
S	0.999518	0.999370	0.998952
Y	0.999206	0.999206	0.999206
PW	0.999773	0.999700	0.999700
PL	0.996984	0.996984	0.995709
PY	1.002104	1.002104	1.002104
L	0.997233	0.997233	1.003909
AC	0.998974	0.998974	1.000477
D	0.997551	0.997551	0.997551
MB	0.998974	0.998974	1.000477
E	0.992077	0.992077	0.994733
AT	0.999828	0.999828	1.001450
PA	1.001749	1.001749	1.001749

a_4

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	0.968978	1.095560	1.095560
C	2.037620	1.598260	1.598260
H	1.770670	1.174800	1.174800
B	2.336270	1.415990	1.381630
S	1.750510	1.532270	1.110150
Y	0.301423	0.301423	0.301423
PW	1.676930	1.571030	1.571030
PL	0.745750	0.745750	0.583403
PY	0.566217	0.566217	0.566217
L	0.747048	0.747048	1.880250
AC	0.706093	0.706093	0.731911
D	0.599235	0.599235	0.599235
MB	0.706093	0.706093	0.731911
E	0.865974	0.865974	1.021680
AT	0.424473	0.424473	0.695143
PA	1.377540	1.377540	1.377540

a_5

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	-0.190913	-0.202191	-0.202191
C	-0.486492	-0.411541	-0.411541
H	-0.329190	-0.263576	-0.263576
B	-0.502311	-0.325671	-0.306534
S	-0.408021	-0.364679	-0.281544
Y	-0.040792	-0.040792	-0.040792
PW	-0.372195	-0.369344	-0.369344
PL	-0.130177	-0.130177	-0.077654
PY	-0.087141	-0.087141	-0.087141
L	-0.133729	-0.133729	-0.401856
AC	-0.096789	-0.096789	-0.084192
D	-0.033036	-0.033036	-0.033036
MB	-0.096789	-0.096789	-0.084192
E	-0.106757	-0.106757	-0.141481
AT	-0.037553	-0.037553	-0.039652
PA	-0.286807	-0.286807	-0.286807

a_6

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	0.825961	0.967329	0.967329
C	2.632080	2.402420	2.402420
H	2.185610	2.233330	2.233330
B	4.154490	2.793270	2.637080
S	2.659000	2.741210	2.125100
Y	-1.235630	-1.235630	-1.235630
PW	2.567510	2.703200	2.703200
PL	0.558818	0.558818	-0.036267
PY	-0.063450	-0.063450	-0.063450
L	0.397110	0.397110	3.082780
AC	0.312724	0.312724	0.196339
D	-0.261339	-0.261339	-0.261339
MB	0.312724	0.312724	0.196339
E	0.257139	0.257139	0.641499
AT	-0.517540	-0.517540	-0.603404
PA	1.038780	1.038780	1.038780

a_7

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	0.048766	0.081696	0.081696
C	0.109094	0.094283	0.094283
H	0.105050	0.045184	0.045184
B	0.086560	0.108427	0.163996
S	0.092651	0.117756	0.148340
Y	0.030743	0.030743	0.030743
PW	0.071928	0.049628	0.049628
PL	0.198687	0.198687	0.142531
PY	0.071720	0.071720	0.071720
L	0.078345	0.078345	0.276300
AC	0.119634	0.119634	0.148285
D	0.215536	0.215536	0.215536
MB	0.119634	0.119634	0.148285
E	0.254574	0.254574	0.258921
AT	0.102211	0.102211	0.193706
PA	0.072537	0.072537	0.072537

a_8

Species	F.I.Z. A, B & C	F.I.Z. D - J	F.I.Z. K & L
F	-0.426214	-0.514604	-0.514604
C	-1.486550	-1.252170	-1.252170
H	-1.192970	-1.002020	-1.002020
B	-2.186240	-1.326790	-1.292080
S	-1.396760	-1.362760	-1.005560
Y	0.672879	0.672879	0.672879
PW	-1.340830	-1.334700	-1.334700
PL	-0.324178	-0.324178	-0.022523
PY	0.051415	0.051415	0.051415
L	-0.183542	-0.183542	-1.661550
AC	-0.080057	-0.080057	-0.069852
D	0.123059	0.123059	0.123059
MB	-0.080057	-0.080057	-0.069852
E	-0.149926	-0.149926	-0.359508
AT	0.303931	0.303931	0.209159
PA	-0.647372	-0.647372	-0.647372

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