SUSTAINABLE RESOURCE DEVELOPMENT

ALBERTA SCALING MANUAL

APPENDICES

11.0 Appendices

SUSTAINABLE RESOURCE DEVELOPMENT

Appendix 1 – Application for Scale Site

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APPLICATION FOR SCALE SITE

NAME: ______________________ ______________________ MILL NUMBER ________

MAILING ADDRESS: [ ]

TELEPHONE: _________________________ SITE LOCATION: ___________________________________

APPLICATION FOR: ☐ MASS SCALE SITE ☐ NON-MASS SCALE SITE

REQUESTED DATE FOR IMPLEMENTATION: ___________________________

EXISTING INVENTORY - ROUNDWOOD VOLUME: _______________

- PRODUCT VOLUME: _______________

FOR MASS SCALE SITES:

SCALER: ______________________ PERMIT # ____________ EXPIRY DATE: _________________

______________________ ____________ _________________

MAKE OF SCALE: ___________________________________ CERTIFICATION DATE: _________________

LENGTH OF SCALE: _________________ SCALE CAPACITY: ____________________

SCALE SOFTWARE: ___________________________________ SCALE ATTENDANT (yes or no): _______

FOR NON-MASS SCALE SITES:

SPECIES: ____________________ ESTIMATED VOLUME: ____________ PRODUCT: ____________

TREELENGTH (yes or no): _______ SHORTWOOD (yes or no): _______ SHORTWOOD LENGTH: _____

SITE OWNER: ______________________________ LFD REPRESENTATIVE: ______________________________

SIGNATURE: ______________________________ SIGNATURE: ______________________________

DATE: ______________________________ DATE: ______________________________

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Appendix 2 - Mass Scaling for the Smaller Timber Operation

Application

There are many smaller timber operations in Alberta who do not have the assurance of a defined long-term wood supply, and an on-site weigh scale for timber harvest accounting is not an economic reality.

Weigh scale accounting of harvested timber is a proven and effective method authorized by the Public Land and Forest Division (PLFD). To make this system possible for smaller timber operations, the use of departmental approved weigh scales owned by another person/company will be considered. These approvals are deviations from standard accepted practices and are therefore limited to the following:

Operations which currently determine the harvested volumes on a manufacture basis and which are:

1. Processing community timber and/or directed FMA incidental (and which may include private or salvage) timber.

2. Approved by the local PLFD area office for this purpose. (Refer to "Agreement").

To obtain consideration for mass scaling the first step is to complete a "Mass Scaling Agreement". (Refer to sample form). This form is to be fully completed by all parties and a copy forwarded to the Provincial Scaling Supervisor.

Before a PLFD representative signs the form that person will address inventories, fixed tare weight determinations, and ensure all mass scaling practices and are in place with the timber operator. (Refer to those sections following the sample form).

Mass Scaling Agreement

I, ______________________________ of ____________________________________,

have read, and understand, the requirements of weigh scale accounting for timber (attached). I hereby request that all timber, or as otherwise directed by the Public Land and Forest Division (PLFD), which is delivered to my mill (processing site) located at __________________________________, be accounted for by weighing across the weigh scales of _______________________________. Sample log scaling or the application if fixed weight to volume ratios will be implemented as directed by the PLFD. The request date for commencing weigh scale accounting is __________________. I am in agreement to follow proper procedures for weigh scale accounting and that I shall maintain and submit weigh scale records to the PLFD as required. I further understand that I am to abide by all relevant legislation in the Forests Act and its associated regulations, and that failure to do so may result in penalty action and/or forfeiture of this agreement.

Applicant

Signed: ________________________

Printed Name: ________________________

Date: ________________________

Weigh Scale Owner

Signed: ________________________

Printed Name: ________________________

Date: ________________________

Public Land and Forest Division Representative

Printed Name: ________________________

Date: ________________________

Phone Number: ________________________

Signature: ________________________

Handling Existing Inventory

Manufactured products and log inventory hauled into a yard prior to approving the use of the weigh scale is to be segregated from weigh scaled timber. Timber manufactured and sold under the non-scale system is reported separately.

Scale Populations

Scaling populations and sample intensities are to be established through discussions with the Forest Area and Company. Form TM262 " Scaling Populations", is to be completed each timber year.

Weighing

1. Weights and date/times are to be printed on every load ticket (using a printer attached to the weigh scale).
2. Gross weights are to be taken for every load.
3. Tare weights will be required for every sample load and are to be taken immediately after unloading.
4. Average tare weights will be accepted providing the procedures for establishing and testing fixed tare weights is followed (Refer to the section below titled "Procedure for Average Tare Weights").

Sample Load Selection and Scaling

- Where sample loads are requested, sample cards or random load generators will be used to select the scale loads as they cross the scale.
- Sample scale trees are to be bucked and the scaling is to be done by a permitted scaler.
- The scale loads are to be left in the same condition as they were scaled until checked scaled or released by the local PLFD area staff.

Weigh Scale Records

- A mill number and mill code will be assigned by the Forest Management Branch of the PLFD, and which are to be used on all records requiring such.
- The weigh scale information must be summarized on departmental approved forms and submitted within 21 days following each month of weigh scale activity.
- Forms which must be completed and submitted include the TM35 "Weigh Scale Load Record Sheet" and TM44 "Volume Compilation Sheet". The sample scale loads are to be compiled using the Micro Logscale program and submitted on a computer disk along with the other required scale forms.
- Unless authorized by PLFD area staff, all timber including private and salvage timber hauled to the mill site is to be accounted for by the weigh scale process.

Procedure for Average Tare Weights

Weigh scaling for the smaller timber operator provides for the use of average tare weights. This acceptance of this practice will be subject to the following requirements:

1. The average tare must be based on at least 10 sample weights for each truck. If a truck changes configuration the average must be re-established by the same process.

2. The average tare weight for any one truck must not have a coefficient of variation of more than ± 2%. Trucks having a variance of more than ± 2% must continue to reweigh out until the variance is within range.

3. The average tare must be randomly sampled at a minimum of 20 load intervals to determine if the weight is still within ± 2% of the average. If not, repeat step 1.

4. Calculation of the average tare and the variance must be documented and included with scale data submissions.

The average tare cannot be used for sample loads. The trucks must obtain tare weights for sample loads.

Calculation of Average Tare and Variance

Truck	Tare Weight (kg)	Difference from Average	Difference Squared
1	15350	4	16
	15240	114	12996
	15360	-6	36
	15310	44	1936
	15390	-36	1296
	15260	94	8836
	15160	194	37636
	15490	-136	18496
	15350	4	16
	15630	-276	76176
	153540		157440

$$\text{Average tare} = \frac{153540}{10} = 15354$$

$$SD = \sqrt{\frac{157440}{(10-1)}} = \pm 132 \qquad C.V.\ \% = \frac{SD}{\text{Avg. Tare}} \times 100\% = 0.86\%$$

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Appendix 3 – Example of Mass Scale Analysis

Load No.	Net Weight	Sw & Pl Scale	Fb Scale	Total Scale	Scale Estimate	Diff.	$Diff.^2$
38	43 400	42.196	0.000	42.196	51.764	+9.568	91.547
81	36 360	41.682	0.000	41.682	43.367	+1.685	2.839
174	48 220	60.829	0.000	60.839	57.513	-3.326	11.062
19	43 400	56.057	1.161	57.218	51.764	+5.454	29.746
38	37 780	49.188	1.708	50.896	45.061	-5.835	34.047
141	50 220	55.902	0.000	55.902	59.898	+3.996	15.968
153	44 980	50.001	0.487	50.488	53.648	+3.160	9.986
256	38 460	44.845	0.123	44.968	45.872	+0.904	0.817
277	44 760	53.628	1.021	54.649	53.386	-1.263	1.595
177	41 960	49.816	3.666	53.482	50.046	-3.436	11.806
	429 540			512.320	512.319		209.413

$$\text{Ratio} = \frac{429540}{512.320} = 838.421 \qquad \text{Avg. Volume/Load} = \frac{512.320}{10} = 51.232$$

$$\text{SD} = \sqrt{\frac{209.413}{(10-1)}} = 4.823 \qquad \text{CV\%} = \frac{4.823x100}{51.232} = 9.41\%$$

Projected Cut: 5,000,000 fbm (21 500 m^3)

$$N = \frac{21.500}{51.232} = 420 \text{ loads}$$

$$n = \frac{Nt^2C^2}{NE^2 + t^2C^2}$$

Where:
n = number of samples
N = number of loads
t = probability (2)
E = allowable sampling error

1st Calculation

$$n = \frac{420(2)^2 x(9.41)^2}{420(5)^2 + [(2)^2 x(9.41)^2]} = \frac{148761}{10854} = 13.7 \text{ (14 samples)}$$

Revised t = (14-1 = 13) =2.16

2nd Calculation

$$n = \frac{420(2.16)^2 x(9.41)^2}{420(5)^2 + [(2.16)^2 x(9.41)^2]} = \frac{173515}{10913} = 15.8 \text{ (16 samples)}$$

$$\% \text{ Sampling} = \frac{15.8}{420} x100 = 3.7 = 4\%$$

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Appendix 4 - Tree Length Scaling

Example of Calculation of Sampling Intensity for Butt Distribution

Sample Number	Stems	Sample Volume m^3 (1000x)	Average Vol./Stem m^3 (1000x)	Difference from Group Estimate	Difference Squared
1	24	14 753	615	-216	46656
2	20	25 536	1 277	446	198916
3	27	26 427	979	148	21904
4	11	9 490	863	32	1024
5	29	26 427	911	80	6400
6	19	12 064	635	-196	38416
7	9	7 975	886	55	3025
8	23	19 731	858	27	729
9	19	13 151	692	-139	19321
10	23	14 013	609	-222	49284
	204	169 567	831		385675

Total stems tallied = 4000

Avg. trees/sample 204/10= 20.4

$$\sum D^2 = 385675$$

$$SD = \sqrt{\frac{385\,675}{(10-1)}} = 207$$

$$\text{Avg. volume/stem} = \frac{169\,567}{204} = 831$$

$$C.V.\% = \frac{207 \times 100}{831} = 24.9\%$$

$$n = \frac{Nt^2C^2}{NA^2 + t^2C^2}$$

Where: $N = 4000/20.4 = 196$
$t = 2$
$A = 5$
$C = 24.9$

$$n = \frac{196(2)^2(24.9)^2}{196(5)^2+(2)^2(24.9)^2} = 66 \text{ samples}$$

$$\% \text{ sampling} = \frac{66 \times 100}{196} = 33.7\%$$

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Appendix 5 – Common Stains and Defects Found When Scaling

STAINS

1. Red Heart Stain - Pine and Spruce

This is an early stage of *Phellinus pini* (Thore:Fr.) Ames, referred to as white pitted rot or white pocket rot. This rot generally attacks pine and spruce, but does not advance after the tree is cut. The stained wood is as strong as unstained wood and can be used for building construction except where extra strength or unstained appearance is required. Various stages of the rot are referred to as white speck and honeycomb. Firm white speck is still acceptable in the middle grades of lumber.

2. Red Brown Stain - Balsam Fir

This is an early stage of *Haematostereum sanguinolentum* (Alb. and Sch.:Fr.) Fir., referred to as red heart rot. The rot first shows as a firm red-brown stain, often in streaks. The decay does not advance after the tree has been cut, and the stained wood is not significantly weaker than unstained material. Also, the pulp strength is not likely to be affected by the stain.

3. Red stain - Aspen

This stain is a result of *Peniophora polygonia* (Pers.:Fries) Bourd. & Galzin, resulting in stained columns coming from infected branches in aspen. The stained wood is suitable for pulp and oriented strandboard with some considerations. There can be some rot pockets or ring separation from an associated rot, which will result in extra fines in the oriented strand- board wafers or in pulp chips. As well, if the material is used for CTMP pulp, bleaching out the stain may be a problem.

4. Blue stain - All species

Blue stain often develops in stored logs or on dead trees. This stain often results from mountain pine beetle attacks. It has the most effect on CTMP pulping processes because of the added bleaching cost. Since the stain develops mainly after logging and during storage of the wood, damage can be controlled or prevented to some extent. For kraft pulp processes, oriented strandboard and lumber products, the stain does not present any strength problems.

5. Black stain - Black Poplar

This stain is seen as greyish-black with some brownish pockets and is common in black poplar. Although black stain eliminates the use of black poplar for the CTMP pulping process, it can be bleached out in the kraft pulp processes.

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HEART OR STEM ROTS

1. White Pitted Rot or White Pocket Rot (*Phellinus pini* [Thore:Fr.] Ames)

This rot generally attacks pine and spruce. The first stage is referred to as red stain. The stained area is as strong as unstained wood. The rot does not advance after the tree is cut. Various stages of the rot are referred to as white speck and honeycomb. Firm white speck is still acceptable in the middle grades of lumber. Wood with advanced rot (honeycomb) is usually quite weak, although it is used for the bottom grades of lumber providing it holds together. It is appropriate to make deductions for honeycomb.

2. Red Heart Rot (*Haematostereum sanguinolentum* [Alb. & Sch.:Fr.] Fir.)

This rot is usually associated with balsam fir. The rot first shows as a firm red-brown stain, often in streaks. As it advances, a white rot develops that is light to red-brown in colour, and dry and somewhat stringy. In logs, it usually forms a circular mass around the pith. The most serious problem with the rot is that it causes separation in the annual rings, thus degrading the lumber. In making deductions, look for the white rot developing along the annual rings.

3. White Heart Rot (*Phellinus tremulae* [Bond.] Bond. & Boriss., *Phellinus igniarius* [Linnaeus:Fries] Quel., *Fomes igniarius* [Linnaeus:Fries] J.Kickx fil.)

This is the most common trunk rot that attacks aspen in Alberta. A prominent black line surrounds and often occurs within the decayed areas. The rot is a yellowish to white colour and has a soft and spongy texture. This rot is very weak and usually crumbles when put through chippers or wafer machines.

BUTT OR ROOT ROTS

1. Armillaria Butt Rot (mostly *Armillaria ostoyae* [Romagn.] Herink)

Can attack either coniferous or deciduous trees. The yellow, stringy rot is often covered by dark brown fungal material mixed with wood. The decay occurs at the bottom of the tree and tapers off quickly, seldom extending more than 1 m up the tree.

2. Brown Cubical Rot (*Coniophora puteana* [Schum.:Fries] Karst.)

Frequently found as a butt rot in pine and spruce. The decay usually tapers off quickly. This rot is usually referred to in lumber grading as soft rot and is normally trimmed off to make better grades. Deductions for small isolated pockets can be made by making a visual deduction of 1 to 10 cubes.

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Appendix 6 -Definitions

Accuracy - means the degree of agreement with an accepted reference value of individual measurements, test, or observations made under prescribed conditions, or of estimates computed from them, and refers to the success of estimating the true value of quantity

Bark - means all the tissues, including the cambium, taken collectively and forming the exterior covering of the xylem of a tree.

Bias - means consistent or systematic error that will be of the same amount in all individuals of a set of measurements made under similar circumstances; alternatively, a systematic distortion due to some flaw in measurement, to the method of selecting the sample, or to the technique of estimating the parameter.

Bolt - means any short log specifically cut to length

Butt end – the end of larger diameter usually the stump end.

Butt swell - means that part of a log outside its normal taper and extending from where the normal taper ends and the flare begins to the large end of the log.

Catface – means a defect on the surface of a tree or log resulting from a wound where healing has not re-established the normal cross section.

Check – means a lengthwise separation of the wood in a log or piece of timber, which usually extends across the rings of annual growth, commonly resulting from stresses set up in the wood during seasoning.

Coefficient of variation – means an expression of variability among units in the form of the ratio of the standard deviation(s) to the mean (x) and is usually expressed by the formula C = s/x

Crook – means an abrupt bend or curvature in the length of a log.

Decay – the decomposition of wood substance caused by the action of wood-destroying fungi, resulting in softening, loss of strength and mass, and often change of texture and colur.

Advanced decay – the late stage of decay in which the decompostion is readily recognized, as the wood becomes punky, soft, stringy, pitted or crumbly. Heart rot – means any rot characteristically confined to the heartwood. It generally originates in the living tree.

Butt rot – means any decay or rot developing in, and sometimes characteristically confined to, the base or lower stem of a tree

Heart rot – any rot generally confined to the heartwood.

Pocket rot – any rot localized in small areas , generally forming rounded or len-shaped cavities, honeycomb decay.

Ring rot – any rot localized mainly in the earlywood of the annual rings, giving a concentric pattern of decayed wood in cross section.

Sap rot – means any rot characteristically confined to the sapwood.

Defect – means any of the following imperfections occurring in and affecting the utility of logs: advanced decay, charred wood, and missing wood.

Fork – means a division of a log or a stem of a tree into two or more branches

Fuelwood – means roundwood, whole or split, produced for burning.

Hardwoods – trees of the botanical group that generally have broad leaves, in contrast to the conifers. The term has no reference to the actual hardness of the wood.

Heart shake – means a shake that originates at the pith of a log and extends across the annual rings.

Heartwood – means the inner core of a woody stem wholly composed of nonliving cells and usually differentiated from the outer enveloping layer (sapwood) by its darker colour. It is usually more decay resistant than sapwood.

Local volume table – means a table showing, for one or more species, the average cubic contents for tree lengths by diameter classes, within a smaller geographic region.

Mass – means the property of a body that is a measure of its inertia that is commonly taken as a measure of the amount of material it contains, and that causes it to have weight in a gravitational field.

Moisture content – means the mass of water in wood expressed as a percentage of its total mass.

Net Volume – means the volume remaining after all deductions for defect from gross volume have been made; in stacked measure, deductions include voids.

Ovendry – means a condition in which the wood has ceased to lose moisture after being subjected to a temperature of 103 +/-2^{0}C in a ventilated oven, for purposes of determining moisture content.

Piece – means a part of a whole (as of a tree)

Pile face – means, in tree-length scaling, the surface formed by butt ends that have been piled with the butts all aligned in a nearly vertical plane.

Precision – means the closeness of agreement among a set of measurements made under prescribed conditions, and refers to the clustering of sample values about their own average.

Roundwood – means any section of the stem, or of the thicker branches, of a tree of commercial value that has been felled or cut but has not been processed beyond removing the limbs or bark, or both, or splitting the section (for fuelwood).

Sample size – means the number of items, specimens, observations, or measurements to be included in the sample.

Sampling Error – the difference between a true value for a population and an estimate of this value, which is due to the fact that only sample values are being observed. The standard error is a measure of the sampling error.

Sapwood – means the living wood of pale colour near the outside of the log. Under most conditions the sapwood is more susceptible to decay than heartwood.

Scale – means the measured or estimated quantity, expressed as the volume, or area, or length, or mass, or number of products obtained from trees after they are felled.

Scaler – means a person qualified to scale primary forest products and usually licensed or appointed by a government agency.

Shake – means a separation along the grain of a log or tree and occurring between or across the annual rings but not extending from one surface to another.

Ring shake – means a shake that partially or completely encircles the pith.

Softwood – means, generally, one of the botanical groups of trees that in most cases have needle or scale like leaves; the conifers. The term has no reference to the actual hardness of the wood.

Stack – means, for scaling purpose, an orderly arrangement of bolts less than or equal to the 2.60 m class in length.

Stacked cubic metre – means the total amount of wood, bark, and airspace contained in a stack of roundwood, as determined by its external dimensions, equal to 1 m^3.

Standard deviation – means the square root of the variance, and is symbolized by s.

Standard error of the mean – a measure of the variability of the sample means.

Sweep – means a gradual curve in the length of a log, as distinct from an abrupt bend or curvature.

Taper – means the progressive decrease or increase in the diameter of a log from one end or point on its length to another.

Tolerance – means the total range of variation permitted for a required size.

Tree length – the bole of a tree that has been felled, had the top removed, and generally but not necessarily been limbed.

Variance (of a population) – means a measure of the dispersion of individual unit values about their mean.

Wood – means the hard fibrous substance, basically xylem, that makes up the greater part of the stems and branches of trees or shrubs, beneath the bark.

Woodchip – a small, thin, flat piece of wood cut from a larger piece of wood by knife action, mechanically operated. A woodchip shall show two knife cuts and its width shall always be greater than its thickness.

Appendix 7

SCALING TABLES

1. Basal Area   Basal Area
2. Volume of Cylinders   Volume of Cylinders
3. t Adjustment Table   t Adjustment Table
4. Samples Required   Samples Required
5. Percent Samples Required   Percent Samples Required
6. Summary of General Conversion Factors Conversion Factors
7. Smalian Half Volume Table   Smalian 1/2 Volume Table

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Table 1 - Basal Area -m^2 (1000x)			
Diameter (cm)	**Basal Area**	**Diameter (cm)**	**Basal Area**
4	**1**	**42**	**139**
6	**3**	**44**	**152**
8	**5**	**46**	**166**
10	**8**	**48**	**181**
12	**11**	**50**	**196**
14	**15**	**52**	**212**
16	**20**	**54**	**229**
18	**25**	**56**	**246**
20	**31**	**58**	**264**
22	**38**	**60**	**283**
24	**45**	**62**	**302**
26	**53**	**64**	**322**
28	**62**	**66**	**342**
30	**71**	**68**	**363**
32	**80**	**70**	**385**
34	**91**	**72**	**407**
36	**102**	**74**	**430**
38	**113**	**76**	**454**
40	**126**	**78**	**478**

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Table 2 - Volume of Cylinders - m^3 (1000x)

Diameter (cm)	Length 2.4 m	Length 2.6 m	Diameter (cm)	Length 2.4 m	Length 2.6 m
4	2	3	**44**	365	395
6	7	8	**46**	398	432
8	12	13	**48**	434	471
10	19	21	**50**	470	510
12	26	29	**52**	509	551
14	36	39	**54**	550	595
16	48	52	**56**	590	640
18	60	65	**58**	634	686
20	74	81	**60**	679	736
22	91	99	**62**	725	785
24	108	117	**64**	773	837
26	127	138	**66**	821	889
28	149	161	**68**	871	944
30	170	185	**70**	924	1001
32	192	208	**72**	977	1058
34	218	237	**74**	1032	1118
36	245	265	**76**	1090	1180
38	271	294	**78**	1147	1243
40	302	328	**80**	1207	1308
42	334	361			

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Table 3 - t ADJUSTMENT TABLE

Calculated (n-1)	*Revised t*	*Calculated (n-1)*	*Revised t*
1	**12.70**	**16**	**2.12**
2	**4.30**	**17**	**2.11**
3	**3.18**	**18**	**2.10**
4	**2.78**	**19**	**2.09**
5	**2.57**	**20**	**2.09**
6	**2.45**	**21**	**2.08**
7	**2.36**	**22**	**2.07**
8	**2.31**	**23**	**2.07**
9	**2.26**	**24**	**2.06**
10	**2.23**	**25**	**2.06**
11	**2.20**	**26**	**2.06**
12	**2.18**	**27**	**2.05**
13	**2.16**	**28**	**2.05**
14	**2.14**	**29**	**2.05**
15	**2.13**		

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Table 4 - Samples Required

(t = 2, A = ±5%)

Coefficient of Variation %

Total Loads/ Trees	2	3	4	5	6	7	8	9	10	11	12
100	13	13	13	13	13	13	14	16	18	20	22
200	13	13	13	13	13	13	15	17	19	21	24
300	13	13	13	13	13	13	15	17	19	22	25
400	13	13	13	13	13	13	15	17	20	23	26
500	13	13	13	13	13	14	15	17	20	23	26
600	13	13	13	13	13	14	15	17	20	23	26
700	13	13	13	13	13	14	15	17	20	23	26
800	13	13	13	13	13	14	15	18	20	23	26
900	13	13	13	13	13	14	16	18	20	23	26
1000	13	13	13	13	13	14	16	18	20	23	26
1100	13	13	13	13	13	14	16	18	20	23	26
1200	13	13	13	13	13	14	16	18	20	23	26
1300	13	13	13	13	13	14	16	18	20	23	26
1400	13	13	13	13	13	14	16	18	20	23	26
1500	13	13	13	13	13	14	16	18	20	23	26
1600	13	13	13	13	13	14	16	18	20	23	26
1700	13	13	13	13	13	14	16	18	20	23	26
1800	13	13	13	13	13	14	16	18	20	23	27
1900	13	13	13	13	13	14	16	18	20	23	27
2000	13	13	13	13	13	14	16	18	20	23	27
2100	13	13	13	13	13	14	16	18	20	23	27
2200	13	13	13	13	13	14	16	18	20	23	27
2300	13	13	13	13	13	14	16	18	20	23	27
2400	13	13	13	13	13	14	16	18	20	23	27
2500	13	13	13	13	13	14	16	18	20	23	27
2600	13	13	13	13	13	14	16	18	20	23	27
2700	13	13	13	13	13	14	16	18	20	23	27
2800	13	13	13	13	13	14	16	18	20	23	27
2900	13	13	13	13	13	14	16	18	20	23	27
3000	13	13	13	13	13	14	16	18	20	23	27
3100	13	13	13	13	13	14	16	18	20	23	27
3200	13	13	13	13	13	14	16	18	20	23	27
3300	13	13	13	13	13	14	16	18	20	23	27
3400	13	13	13	13	13	14	16	18	20	23	27
3500	13	13	13	13	13	14	16	18	20	23	27
3600	13	13	13	13	13	14	16	18	20	23	27
3700	13	13	13	13	13	14	16	18	20	23	27
3800	13	13	13	13	13	14	16	18	20	23	27
3900	13	13	13	13	13	14	16	18	20	23	27
4000	13	13	13	13	13	14	16	18	20	23	27
4100	13	13	13	13	13	14	16	18	20	23	27
4200	13	13	13	13	13	14	16	18	20	23	27
4300	13	13	13	13	13	14	16	18	20	23	27
4400	13	13	13	13	13	14	16	18	20	23	27
4500	13	13	13	13	13	14	16	18	20	23	27
4600	13	13	13	13	13	14	16	18	20	24	27
4700	13	13	13	13	13	14	16	18	20	24	27
4800	13	13	13	13	13	14	16	18	20	24	27
4900	13	13	13	13	13	14	16	18	20	24	27
5000	13	13	13	13	13	14	16	18	20	24	27

Note: Adjustments have been made to t and CV values when the numbers of samples are below 30.

SUSTAINABLE RESOURCE DEVELOPMENT

Table 4 (cont'd) - Samples Required

(t = 2, A = ±5%)

Coefficient of Variation %

Total Loads/ Trees	13	14	15	16	17	18	19	20	21	22	23
100	24	26	27	29	32	34	37	39	41	44	46
200	27	30	31	34	38	41	45	48	52	56	59
300	28	30	32	36	40	44	48	53	57	62	66
400	29	30	33	37	41	46	50	55	60	65	70
500	29	30	34	38	42	47	52	57	62	67	72
600	30	30	34	38	43	48	53	58	63	69	74
700	30	30	34	39	43	48	53	59	64	70	76
800	30	30	34	39	44	49	54	59	65	71	77
900	30	30	35	39	44	49	54	60	65	71	77
1000	30	30	35	39	44	49	55	60	66	72	78
1100	30	30	35	39	44	50	55	60	66	72	79
1200	30	31	35	40	45	50	55	61	67	73	79
1300	30	31	35	40	45	50	55	61	67	73	79
1400	30	31	35	40	45	50	55	61	67	73	80
1500	30	31	35	40	45	50	56	61	67	74	80
1600	30	31	35	40	45	50	56	62	68	74	80
1700	30	31	35	40	45	50	56	62	68	74	81
1800	30	31	35	40	45	50	56	62	68	74	81
1900	30	31	35	40	45	50	56	62	68	74	81
2000	30	31	35	40	45	51	56	62	68	75	81
2100	30	31	35	40	45	51	56	62	68	75	81
2200	30	31	35	40	45	51	56	62	68	75	82
2300	30	31	35	40	45	51	56	62	68	75	82
2400	30	31	35	40	45	51	56	62	68	75	82
2500	30	31	35	40	45	51	56	62	69	75	82
2600	30	31	36	40	45	51	57	62	69	75	82
2700	30	31	36	40	45	51	57	63	69	75	82
2800	30	31	36	40	45	51	57	63	69	75	82
2900	30	31	36	40	46	51	57	63	69	75	82
3000	30	31	36	40	46	51	57	63	69	75	82
3100	30	31	36	40	46	51	57	63	69	76	82
3200	30	31	36	40	46	51	57	63	69	76	82
3300	30	31	36	40	46	51	57	63	69	76	83
3400	30	31	36	40	46	51	57	63	69	76	83
3500	30	31	36	40	46	51	57	63	69	76	83
3600	30	31	36	40	46	51	57	63	69	76	83
3700	30	31	36	41	46	51	57	63	69	76	83
3800	30	31	36	41	46	51	57	63	69	76	83
3900	30	31	36	41	46	51	57	63	69	76	83
4000	30	31	36	41	46	51	57	63	69	76	83
4100	30	31	36	41	46	51	57	63	69	76	83
4200	30	31	36	41	46	51	57	63	69	76	83
4300	30	31	36	41	46	51	57	63	69	76	83
4400	30	31	36	41	46	51	57	63	69	76	83
4500	30	31	36	41	46	51	57	63	69	76	83
4600	30	31	36	41	46	51	57	63	69	76	83
4700	30	31	36	41	46	51	57	63	70	76	83
4800	30	31	36	41	46	51	57	63	70	76	83
4900	30	31	36	41	46	51	57	63		76	83
5000	30	31	36	41	46	51	57	63	70	76	83

Note: Adjustments have been made to t and CV values when the numbers of samples are below 30.

Table 5 - Percent Samples Required

(t = 2, A = ±5%)

Coefficient of Variation %

Total Loads/ Trees	2	3	4	5	6	7	8	9	10	11	12
100	13.0	13.0	13.0	13.0	13.0	13.2	14.4	16.0	17.7	19.8	22.0
200	6.5	6.5	6.5	6.5	6.5	6.5	7.3	8.4	9.4	10.7	12.1
300	4.3	4.3	4.3	4.3	4.3	4.4	5.0	5.7	6.5	7.4	8.4
400	3.3	3.3	3.3	3.3	3.3	3.3	3.8	4.3	4.9	5.6	6.3
500	2.6	2.6	2.6	2.6	2.6	2.7	3.0	3.4	3.9	4.5	5.1
600	2.2	2.2	2.2	2.2	2.2	2.2	2.5	2.9	3.3	3.8	4.3
700	1.9	1.9	1.9	1.9	1.9	1.9	2.2	2.5	2.8	3.2	3.7
800	1.6	1.6	1.6	1.6	1.6	1.7	1.9	2.1	2.5	2.8	3.2
900	1.4	1.4	1.4	1.4	1.4	1.5	1.7	1.9	2.2	2.5	2.9
1000	1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.7	2.0	2.3	2.6
1100	1.2	1.2	1.2	1.2	1.2	1.2	1.4	1.6	1.8	2.1	2.3
1200	1.1	1.1	1.1	1.1	1.1	1.1	1.3	1.4	1.6	1.9	2.1
1300	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.3	1.5	1.7	2.0
1400	0.9	0.9	0.9	0.9	0.9	0.9	1.1	1.2	1.4	1.6	1.8
1500	0.9	0.9	0.9	0.9	0.9	0.9	1.0	1.1	1.3	1.5	1.7
1600	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.1	1.2	1.4	1.6
1700	0.8	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.1	1.3	1.5
1800	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.4
1900	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	1.0	1.2	1.3
2000	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.8	1.0	1.1	1.3
2100	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.9	1.1	1.2
2200	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	0.9	1.0	1.2
2300	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1
2400	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.9	1.1
2500	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.9	1.0
2600	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.9	1.0
2700	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.7	0.8	0.9
2800	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.6	0.7	0.8	0.9
2900	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.8	0.9
3000	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8
3100	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.7	0.8
3200	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.8
3300	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.7	0.8
3400	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.6	0.6	0.7
3500	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.5	0.5	0.6	0.7
3600	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.6	0.7
3700	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.5	0.6	0.7
3800	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.7
3900	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6	0.6
4000	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.6
4100	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6
4200	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6
4300	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6
4400	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.6
4500	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5
4600	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5
4700	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.5	0.5
4800	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.4	0.5
4900	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.4	0.5
5000	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.4	0.4	0.5

Note: Adjustments have been made to t and CV values when the numbers of samples are below 30.

Table 5 (Cont'd) –Percent Samples Required

(t = 2, A = ±5%)

Coefficient of Variation %

Total Loads/ Trees	13	14	15	16	17	18	19	20	21	22	23
100	24.5	26.7	29.2	30.0	31.6	34.1	36.6	39.0	41.4	43.6	45.8
200	13.6	15.0	15.2	17.0	18.8	20.6	22.4	24.2	26.1	27.9	29.7
300	9.3	10.0	10.7	12.0	13.3	14.7	16.1	17.6	19.0	20.5	22.0
400	7.2	7.5	8.2	9.3	10.3	11.5	12.6	13.8	15.0	16.2	17.5
500	5.8	5.9	6.7	7.5	8.4	9.4	10.4	11.3	12.4	13.4	14.5
600	4.9	4.9	5.6	6.3	7.1	7.9	8.8	9.6	10.5	11.4	12.4
700	4.2	4.2	4.8	5.5	6.2	6.9	7.6	8.4	9.2	10.0	10.8
800	3.7	3.7	4.3	4.8	5.4	6.1	6.7	7.4	8.1	8.8	9.6
900	3.3	3.3	3.8	4.3	4.8	5.4	6.0	6.6	7.3	7.9	8.6
1000	3.0	3.0	3.4	3.9	4.4	4.9	5.5	6.0	6.6	7.2	7.8
1100	2.7	2.7	3.1	3.5	4.0	4.5	5.0	5.5	6.0	6.6	7.1
1200	2.5	2.5	2.9	3.3	3.7	4.1	4.6	5.1	5.6	6.1	6.6
1300	2.3	2.3	2.6	3.0	3.4	3.8	4.3	4.7	5.1	5.6	6.1
1400	2.1	2.1	2.5	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7
1500	2.0	2.0	2.3	2.6	2.9	3.3	3.7	4.1	4.5	4.9	5.3
1600	1.8	1.9	2.2	2.4	2.8	3.1	3.5	3.8	4.2	4.6	5.0
1700	1.7	1.8	2.0	2.3	2.6	3.0	3.3	3.6	4.0	4.4	4.7
1800	1.6	1.7	1.9	2.2	2.5	2.8	3.1	3.4	3.8	4.1	4.5
1900	1.5	1.6	1.8	2.1	2.3	2.7	3.0	3.3	3.6	3.9	4.3
2000	1.5	1.5	1.7	2.0	2.2	2.5	2.8	3.1	3.4	3.7	4.1
2100	1.4	1.4	1.6	1.9	2.1	2.4	2.7	3.0	3.3	3.6	3.9
2200	1.3	1.4	1.6	1.8	5.0	2.3	2.6	2.8	3.1	3.4	3.7
2300	1.3	1.3	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.3	3.5
2400	1.2	1.2	1.4	1.6	1.8	2.1	2.4	2.6	2.9	3.1	3.4
2500	1.2	1.2	1.4	1.6	1.8	2.0	2.3	2.5	2.7	3.0	3.3
2600	1.1	1.1	1.3	1.5	1.7	2.0	2.2	2.4	2.6	2.9	3.2
2700	1.1	1.1	1.3	1.4	1.6	1.9	2.1	2.3	2.5	2.8	3.0
2800	1.0	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.7	2.9
2900	1.0	1.0	1.2	1.3	1.5	1.8	2.0	2.2	2.4	2.6	2.8
3000	1.0	1.0	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7
3100	0.9	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.7
3200	0.9	0.9	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6
3300	0.9	0.9	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5
3400	0.8	0.9	1.0	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.4
3500	0.8	0.8	1.0	1.1	1.3	1.5	1.6	1.8	2.0	2.2	2.4
3600	0.8	0.8	0.9	1.1	1.2	1.4	1.6	1.7	1.9	2.1	2.3
3700	0.8	0.8	0.9	1.0	1.2	1.4	1.5	1.7	1.9	2.1	2.2
3800	0.7	0.8	0.9	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2
3900	0.7	0.7	0.9	1.0	1.1	1.3	1.5	1.6	1.8	1.9	2.1
4000	0.7	0.7	0.8	1.0	1.1	1.3	1.4	1.6	1.7	1.9	2.1
4100	0.7	0.7	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.9	2.0
4200	0.7	0.7	0.8	0.9	1.0	1.2	1.4	1.5	1.7	1.8	2.0
4300	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.8	1.9
4400	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1.9
4500	0.6	0.6	0.7	0.9	1.0	1.1	1.3	1.4	1.5	1.7	1.8
4600	0.6	0.6	0.7	0.8	0.9	1.1	1.2	1.4	1.5	1.7	1.8
4700	0.6	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.8
4800	0.6	0.6	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.6	1.7
4900	0.6	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7
5000	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1.7

Note: Adjustments have been made to t and CV values when the numbers of samples are below 30.

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Table 6 - Summary of General Conversion Factors

Conversion factors are generally average values.

Volume

1 cubic metre (m3) = 35.315 cubic feet

1 cord = 128 cubic feet (air and bark)
1 cord = 85 cubic feet (solid)

Fuelwood

Solid means the actual roundwood volume whereas stacked represents the solid volume plus air and bark. Due to the fact that deciduous is less cylindrical and has more branching than coniferous, there is less solid volume for a given cord or stacked m3.

Coniferous

1 cord(solid)= 2.407 m3(solid)
1 m3 (stacked) = 0.664 m3 (solid)

Deciduous

1 cord(solid) = 2.010 m3 (solid)
1 m3 (stacked) = 0.557 m3 (solid)

Lumber

1 m3 = 233 foot board measure (fbm)

Wood Chips

1 bone dry unit = 1.089 tonnes
= 100 cubic feet
= 2.603 m3 (solid)

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Table 7 – Smalian Half Volume Table

SMALIAN SCALE
HALF VOLUMES OF CYLINDERS
M3 (1000x)

Diameter (cm) Inside Bark

Length (m)	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62
0.6	2	2	3	5	6	8	9	11	14	16	18	21	24	27	31	34	38	42	46	50	54	59	64	69	74	79	85	91
0.8	2	3	5	6	8	10	13	15	18	21	25	28	32	36	41	45	50	55	61	66	72	79	85	92	99	106	113	121
1.0	3	4	6	8	10	13	16	19	23	27	31	35	40	45	51	57	63	69	76	83	90	98	106	115	123	132	141	151
1.2	3	5	7	9	12	15	19	23	27	32	37	42	48	54	61	68	75	83	91	100	109	118	127	137	148	159	170	181
1.4	4	5	8	11	14	18	22	27	32	37	43	49	56	64	71	79	88	97	106	116	127	137	149	160	172	185	198	211
1.6	4	6	9	12	16	20	25	30	36	42	49	57	64	73	81	91	101	111	122	133	145	157	170	183	197	211	226	242
1.8	5	7	10	14	18	23	28	34	41	48	55	64	72	82	92	102	113	125	137	150	163	177	191	206	222	238	254	272
2.0	5	8	11	15	20	25	31	38	45	53	62	71	80	91	102	113	126	139	152	166	181	196	212	229	246	264	283	302
2.2	6	9	12	17	22	28	35	42	50	58	68	78	88	100	112	125	138	152	167	183	199	216	234	252	271	291	311	332
2.4	6	9	14	18	24	31	38	46	54	64	74	85	97	109	122	136	151	166	182	199	217	236	255	275	296	317	339	362
2.6	7	10	15	20	26	33	41	49	59	69	80	92	105	118	132	147	163	180	198	216	235	255	276	298	320	343	368	392
2.8	7	11	16	22	28	36	44	53	63	74	86	99	113	127	143	159	176	194	213	233	253	275	297	321	345	370	396	423
3.0	8	12	17	23	30	38	47	57	68	80	92	106	121	136	153	170	188	208	228	249	271	295	319	344	369	396	424	453
3.2	8	13	18	25	32	41	50	61	72	85	99	113	129	145	163	181	201	222	243	266	290	314	340	366	394	423	452	483
3.4	9	13	19	26	34	43	53	65	77	90	105	120	137	154	173	193	214	236	258	283	308	334	361	389	419	449	481	513
3.6	9	14	20	28	36	46	57	68	81	96	111	127	145	163	183	204	226	249	274	299	326	353	382	412	443	476	509	543
3.8	10	15	21	29	38	48	60	72	86	101	117	134	153	173	193	215	239	263	289	316	344	373	404	435	468	502	537	574
4.0	10	16	23	31	40	51	63	76	90	106	123	141	161	182	204	227	251	277	304	332	362	393	425	458	493	528	565	604
4.2	11	16	24	32	42	53	66	80	95	111	129	148	169	191	214	238	264	291	319	349	380	412	446	481	517	555	594	634
4.4	11	17	25	34	44	56	69	84	100	117	135	156	177	200	224	250	276	305	335	366	398	432	467	504	542	581	622	664
4.6	12	18	26	35	46	59	72	87	104	122	142	163	185	209	234	261	289	319	350	382	416	452	488	527	566	608	650	694
4.8	12	19	27	37	48	61	75	91	109	127	148	170	193	218	244	272	302	333	365	399	434	471	510	550	591	634	679	725
5.0	13	20	28	38	50	64	79	95	113	133	154	177	201	227	254	284	314	346	380	415	452	491	531	573	616	661	707	755
5.2	13	20	29	40	52	66	82	99	118	138	160	184	209	236	265	295	327	360	395	432	470	511	552	595	640	687	735	785
5.4	14	21	31	42	54	69	85	103	122	143	166	191	217	245	275	306	339	374	411	449	489	530	573	618	665	713	763	815
5.6	14	22	32	43	56	71	88	106	127	149	172	198	225	254	285	318	352	388	426	465	507	550	595	641	690	740	792	845
5.8	15	23	33	45	58	74	91	110	131	154	179	205	233	263	295	329	364	402	441	482	525	569	616	664	714	766	820	876
6.0	15	24	34	46	60	76	94	114	136	159	185	212	241	272	305	340	377	416	456	499	543	589	637	687	739	793	848	906
6.2	16	24	35	48	62	79	97	118	140	165	191	219	249	281	316	352	390	429	471	515	561	609	658	710	764	819	877	936
6.4	16	25	36	49	64	81	101	122	145	170	197	226	257	291	326	363	402	443	487	532	579	628	680	733	788	845	905	966
6.6	17	26	37	51	66	84	104	125	149	175	203	233	265	300	336	374	415	457	502	548	597	648	701	756	813	872	933	996
6.8	17	27	38	52	68	87	107	129	154	181	209	240	273	309	346	386	427	471	517	565	615	668	722	779	837	898	961	1026
7.0	18	27	40	54	70	89	110	133	158	186	216	247	281	318	356	397	440	485	532	582	633	687	743	802	862	925	990	1057
7.2	18	28	41	55	72	92	113	137	163	191	222	254	290	327	366	408	452	499	547	598	651	707	765	824	887	951	1018	1087