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Using Volume and Taper Equations Developed at Different Breast Heights

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New Zealand

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EXECUTIVE SUMMARY

Three methods of using 1.3m breast height measurements in volume equations for *Eucalyptus nitens* and *saligna* developed from 1.4m measurements were tested.

Substituting $D_{1.3}$ for $D_{1.4}$ results in an over estimate of approximately 2 percent.

Using an average taper to reduce the $D_{1.3}$ measurement produced a more variable result with both over and under estimates, some large.

Calculating the approximate taper between $D_{1.3}$ and $D_{1.4}$ for each tree produced much more accurate estimates. All errors were negative, ie. under estimates, but the largest percentage error was only -0.02%.

1 Introduction

The most important measurement of standing tree size is breast-height diameter over bark (*Dbh*). However the reference height (breast height) at which over-bark diameter (*D*) is measured on a standing tree differs in different countries. New Zealand foresters initially inherited the imperial 4'6" (1.3716m) breast height. On conversion to metric measurement systems (SI units) 4'6" was rounded to 1.4m (the closest decimetre) and this was adopted as metric breast height. Many other countries define breast height as 1.3m.

When *Dbh* is used as a predictor variable in deriving functions to assist with forest mensuration, the breast height used when the measurements were made effectively becomes embedded in the function. Tree volume and taper equations use *Dbh* as an important predictor variable and so are tied to a particular breast height.

Volume and taper equations have been derived for New Zealand grown *Eucalyptus nitens* and *saligna* (Gordon *et al.* 1990, Gordon and Hay 1990). This report examines three estimates of *Dbh* at 1.4m ($D_{1.4}$) that can be derived from *Dbh* at 1.3m ($D_{1.3}$) to determine an estimate which results in a minimum error in predicted volume.

2 Method

Using three different estimates of $D_{1.4}$, total stem volume under bark, and butt log volume under bark (0.4 to 6.4m), were calculated for 5 trees. These trees were chosen to span the range of *Dbh* and height from which the volume and taper equations were based. The three estimates of $D_{1.4}$ were:

2.1 *Dbh* at 1.3m

If the 10 cm difference in breast height is ignored $D_{1.3}$ can simply be substituted for $D_{1.4}$.

2.2 Average Taper

The taper (cm/m) between 1.3m and 1.4m for a tree of average *Dbh* and height can be calculated from the taper equation. This taper can be used to reduce the $D_{1.3}$ measurement to provide an estimate of $D_{1.4}$.

2.3 Iterative

Although the taper equation for *nitens* can be rearranged to provide an equation for Dbh as a function of $D_{1.3}$ and tree height, the taper equation for *saligna* is less tractable and requires numerical methods to solve for Dbh.

An estimate of Dbh for any equation can be determined by first using the taper equation with $D_{1.3}$ as Dbh to calculate the taper between 1.3 and 1.4m. This taper is then used to reduce $D_{1.3}$, effectively combining methods 1 and 2.

3 Results

The results are presented in tables showing the correct volume and estimated volume from the estimated *Dbh*. The error is given in cubic metres and as a percentage of the estimate.

3.1 *saligna* Total Stem Volume

Table 1. *saligna* Total Stem Volume. Method 1.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 1 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.006935	0.007131	0.000196	2.75
40	20	0.908024	0.924803	0.016779	1.81
40	30	1.28835	1.311192	0.022842	1.74
40	40	1.664701	1.69157	0.026869	1.59
70	45	5.839233	5.916816	0.077583	1.31

Table 2. *saligna* Total Stem Volume. Method 2

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 2 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.006935	0.00619	-0.00075	-12.04
40	20	0.908024	0.908852	0.000828	0.09
40	30	1.28835	1.28835	0	0.00
40	40	1.664701	1.661872	-0.00283	-0.17
70	45	5.839233	5.857421	0.018188	0.31

Table 3. *saligna* Total Stem Volume. Method 3.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 3 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.006935	0.006934	-1E-06	-0.01
40	20	0.908024	0.907886	-0.00014	-0.02
40	30	1.28835	1.288205	-0.00015	-0.01
40	40	1.664701	1.664572	-0.00013	-0.01
70	45	5.839233	5.838907	-0.00033	-0.01

3.2 *saligna* Butt log volume

Table 4. *saligna* Butt Log Volume. Method 1.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 1 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.005733	0.005897	0.000164	2.78
40	20	0.503156	0.512454	0.009298	1.81
40	30	0.503113	0.511997	0.008884	1.74
40	40	0.49572	0.503655	0.007935	1.58
70	45	1.535366	1.555595	0.020229	1.30

Table 5. *saligna* Butt Log Volume. Method 2.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 2 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.005733	0.005113	-0.00062	-12.13
40	20	0.503156	0.503615	0.000459	0.09
40	30	0.503113	0.503113	0	0.00
40	40	0.49572	0.494885	-0.00083	-0.17
70	45	1.535366	1.540108	0.004742	0.31

Table 6. *saligna* Butt Log Volume. Method 3.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 3 Volume (m^3)	Error in Volume (m^3)	Percentage Error
5	8	0.005733	0.005732	-1E-06	-0.02
40	20	0.503156	0.503079	-7.7E-05	-0.02
40	30	0.503113	0.503057	-5.6E-05	-0.01
40	40	0.49572	0.495682	-3.8E-05	-0.01
70	45	1,535366	1.535281	-8.5E-05	-0.01

3.3 *nitens* Total Stem Volume

Table 7. *nitens* Total Stem Volume. Method 1.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 1 Volume (m^3)	Error in Volume (m^3)	Percentage Error
6	9	0.010834	0.01105	0.000216	1.95
30	14	0.381141	0.387053	0.005912	1.53
30	21	0.525271	0.533778	0.008507	1.59
30	28	0.658007	0.669067	0.01106	1.65
60	32	2.920619	2.969811	0.049192	1.66

Table 8. *nitens* Total Stem Volume. Method 2.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 2 Volume (m^3)	Error in Volume (m^3)	Percentage Error
6	9	0.010834	0.010184	-0.00065	-6.38
30	14	0.381141	0.380885	-0.00026	-0.07
30	21	0.525271	0.525271	0	0.00
30	28	0.658007	0.658405	0.000398	0.06
60	32	2.920619	2.9461	0.025481	0.86

Table 9. *nitens* Total Stem Volume. Method 3.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 3 Volume (m^3)	Error in Volume (m^3)	Percentage Error
6	9	0.010834	0.010832	-2E-06	-0.02
30	14	0.381141	0.38109	-5.1E-05	-0.01
30	21	0.525271	0.525208	-6.3E-05	-0.01
30	28	0.658007	0.657918	-8.9E-05	-0.01
60	32	2.920619	2.920217	-0.0004	-0.01

3.4 *nitens* Butt Log Volume

Table 10. *nitens* Butt Log Volume. Method 1.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 1 Volume (m^3)	Error in Volume (m^3)	Percentage Error
6	9	0.009137	0.009319	0.000182	1.95
30	14	0.283015	0.287405	0.00439	1.53
30	21	0.307291	0.312267	0.004976	1.59
30	28	0.311598	0.316835	0.005237	1.65
60	32	1.244955	1.265924	0.020969	1.66

Table 11. *nitens* Butt Log Volume. Method 2.

$D_{1.3}$ (cm)	Tree Height (m)	Correct Volume (m^3)	Method 2 Volume (m^3)	Error in Volume (m^3)	Percentage Error
6	9	0.009137	0.008589	-0.00055	-6.38
30	14	0.283015	0.282825	-0.00019	-0.07
30	21	0.307291	0.307291	0	0.00
30	28	0.311598	0.311786	0.000188	0.06
60	32	1.244955	1.255817	0.010862	0.86