NO. 36 TECHNICAL PAPER 1983

DEPARTMENT OF FORESTRY
QUEENSLAND

COMPENDIUM OF VOLUME EQUATIONS FOR PLANTATION SPECIES USED BY THE QUEENSLAND DEPARTMENT OF FORESTRY

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ISSN 0155-9664

ABSTRACT

More then two hundred volume equations for plantation species used by the Queensland Department of Forestry are provided. The history of volume table use, method of computation and four categories of equation: predominant height, total height, merchantable height and small end diameter equations, are described. The specific form and Departmental identification of each equation are given.

INTRODUCTION

The Queensland Department of Forestry has developed over two hundred volume equations which are currently in use. These equations are used to predict volumes to various utilisation limits for all major plantation species, and for many species grown for research purposes. Most of these equations have never been published.

The object of this paper is to collect all the current volume equations, and present them in a convenient form, as well as to give a guide to their use.

The equations reported here may be revised periodically.

HISTORY

Volume tables have been used by the Queensland Department of Forestry to determine the volume of thinnings since plantation thinnings became commercially available during the 1940's. Volume tables were initially prepared for both indigenous forest and plantations using graphical methods, but during the 1940's, statistical least squares techniques were increasingly used. Manual preparation of a volume equation by statistical analysis typically involved some fifteen weeks of effort[1], and some volume equations continued to be estimated by graphical methods until the advent of electronic computers in 1959.

Predominant height was adopted as a volume equation parameter following Haley's[2] investigation of H.R. Gray's hypothesis the 'for any species where predominant height is the same, the same volume table will apply'. Haley[3] concluded that 'volume curves derived from stands of equal predominant height, irrespective of age, spacing, site, etc., are similar for the same species'. Haley makes no mention of Stoate's (1945) work on the derivation of the 'Australian formula'. By 1960, two-way volume tables based on the Australian equation (Spurr 1952) had been compiled for all major plantation species:

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1 *N.B. Henry (1981). Historical development of EDP functions within the Department and current state of these functions, performance and organization. Unpublished mimeograph, 4 pp.*

2 *C. Haley. Unpublished memorandum on Departmental file S/5103 dated 1/2/46.*

3 *C. Haley. Unpublished memorandum on Departmental file 2-4/12 dated 1/8/46.*

$$V = a + bA + cH + dAH \quad (1)$$

where A is sectional area breast high over bark,
H is average predominant height, and
a, b and c are constants.

Spurr's (1952 p. 97 *et seq.*) analysis of volume equations reveals that, of equations using only two variables, the Australian equation is one of the most accurate known. The Australian equation is still employed by the Department to compute total volume and merchantable volume to 7 cm small end (top) diameter under bark (t.d.u.b.).

The incorporation of the reciprocal of sectional area in the equation allows merchantable volumes to 10, 12 and 15 cm t.d.u.b. to be computed more accurately (Spurr 1952, p. 146 *et seq.*; N.B. Henry, unpublished report[1]):

$$V = a + bA + cH + dAH + e/(A + g) + fH/(A + g) \quad (2)$$

where A and H are defined above, and
a, b, c, d, e, f and g are constants.

COMPILATION METHODS

Volume Equation Variables

The principal variables used in volume equations are diameter breast high over bark (DBHOB), predominant height and total height.

DBHOB is measured using a girth tape, to the nearest millimetre diameter. The measurement is taken at 1.3 metres above ground level, and at the high side of the tree if the ground slopes.[2]

Predominant height is determined as the average height of the fifty tallest stems per hectare.[3] In practice, predominant height is determined as the mean local dominant height, where local dominant height is the height of the tallest tree in a 0.02 hectare neighbourhood. Total height is the height of the individual tree.

Computation of Volume Equations

Volume equations are derived using conventional least squares statistical analysis of sample trees collected during thinning operations. Only stems for which both overbark and underbark measurements decrease monotonically with increasing height are included in volume equations.

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1 *N.B. Henry. Unpublished memorandum on Departmental file 204/28 dated 17/2/69.*

2 *Qld Dep. For. Unpublished Exotic Pine Research Manual, p 64.*

3 *As above, p 65.*

Sample trees. For every volume table required, sufficient sample trees are measured to ensure that the entire range of tree sizes is adequately sampled. Further sample trees may be measured to check existing volume equations and to monitor the effects of current management techniques.

Information recorded for each sample tree includes species, location, initial spacing, stand predominant height, thinning stage, age and date of measure. Measurements taken include DBHOB, total height and diameters over- and underbark for a range of heights.[1] Underbark measurements are taken using a girth tape after removal of the bark.

Measurements taken prior to 1973 complied with the imperial standard, girths being taken at the mid-point of each 10 foot (c.3m) section, to facilitate computation of volumes using Huber's formula (Alemdag 1978). Thus girths were recorded at 5 ft, 15 ft, 25 ft, ... etc (c. 1.5 m, 4.6 m, 7.6 m, ... etc). Where a whorl of branches coincided with a measurement point, the mean of measurements taken immediately above and below the whorl was recorded.

The metric standard for sample trees requires diameter measurements to be taken at nominal height 0.2 m, 0.5m., 2.0 m and then at 3.0 m intervals. The actual height at which the diameters are measured may be varied by up to 0.5 m to avoid branch whorls or irregularities in the stem.

Computation of sample tree volume. Prior to the adoption of the metric standard for sample trees in 1973, sample tree volumes were computed using Huber's formula. The adoption of the metric standard which allows variable heights, in 1973, required a more elaborate method to be developed.

In 1974, the first sample trees were measured using the new metric technique. Sample trees were measured at 0.5 m, 2.0 m, 5.0 m . . . . etc. Measurement at 0.2 m did not commence until 1978. Volumes of these first metric sample trees were derived from Smalian's formula using additional diameters extrapolated and interpolated assuming that all portions of the stem, except for a conical tip, approximated frusta or parabolae. This assumption avoided the over-estimation of volume in the neiloid butt region, characteristic of this equation (Alemdag 1978). This approach was used during 1975 and 1976.

When large slash pine stems with pronounced buttswell affecting measurements at 0.5 m were sampled, considerable overestimates of volume in the butt region were apparent. This was directly attributable to deficiencies in Smalian's formula. To overcome this problem, Newton's formula was adopted, and additional diameters were estimated using a more complex method due to Grosenbaugh (1966). Initially, only parabolic projections were used to derive diameter estimates[2], but in 1979, this was found to give rise to unreasonable estimates for certain stems. The technique was then modified to employ parabolic projections for concave frusta, and hyperbolic projections for convex frusta as recommended by Grosenbaugh (1966).

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1 *Qld. Dep. For. Exotic Pine Research Manual, p76.*

2 *R.D. Beck (1976). Volpak. Unpublished mimeograph, 13 pp.*

The current method is to fit concave parabolic or convex hyperbolic functions (Grosenbaugh 1966) to each group of three diameter-height pairs, and interpolate diameter extimates for heights midway between the measured heights.[1] The total volume of the stem, or volume to any height or diameter limit, can be considered as the sum of the volumes of a number of frusta which have the interpolated diameters at their centres and the measured diameters at their ends, plus one or two sections which do not have measurements at both ends. The volumes of the frusta with two diameter measurements and one estimate can be computed from Newton's formula (Alemdag 1978). The volumes of the remaining sections can be computed as the integral of the concave hyperbolae or convex parabolae (Grosenbaugh 1966).

The volume equations are computed using normal least squares regression analysis. The smallest tree admitted in any regression analysis to determine an equation for volume to 7, 10, 12 or 15 cm t.d.u.b., has a DBHOB greater than the largest tree which yields a negative volume. For the major plantation species such as hoop, slash and Caribbean pine over one thousand sample trees from a wide range of diameters and predominant heights, are included in the regression analyses. A typical sampling distribution is presented in Figure 1.

TYPES OF VOLUME EQUATION

Predominant Height Volume Equations

The Australian equation (1), with predominant height is used to compute total volume, and merchantable volume to 7 cm t.d.u.b., for both sale purposes and research use. An important feature of predominant height volume equation is the ease of application, as only average predominant height, and the DBHOB's of the individual trees need be measured. However, the table should be applied only to groups of trees, and not to individuals (Henry 1970, 1979a). Analyses by Henry (1979b) clearly indicate that although the confidence intervals about the estimated volume for a parcel of 100 trees are satisfactory, estimates of individual tree volumes may have confidence limits approaching 50 per cent of the estimate.

This form of equation is also used to compute the volume of the pruned section. The portion of the stem which has been pruned is defined as a log 6.4 metres long for *Pinus taeda* L., and 6.7 m long for all other species in stands pruned to 6.4 m. This length is determined from the pruned height and half the average internode distance less stump height, thus giving rise to a shorter length for loblolly pine.

The volume between 7 cm t.d.u.b. and 10, 12 or 15 cm t.d.u.b. may be predicted by:

$$V = a + E/(A + g) + fH/(A + g) \qquad (3)$$

Merchantable volumes to 10, 12 or 15 cm t.d.u.b. can be determined by the difference between equation (1) and (3) (see Equation 2).

Equation (2) is asymptotic to the merchantable volume to 7 cm t.d.u.b. equation, and is used by the Department for marketing and research use. Predominant height volume equations should only be applied where the average predominant height of the stand exceeds 10 metres.

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1 *J.K. Vanclay. Unpublished memorandum on Departmental file S/51 General dated 16/10/81.*

PREDOMINANT HEIGHT CLASSES (METRES)

DBH CLASS (cm)	10-11.9	12-13.9	14-15.9	16-17.9	18-19.9	20-21.9	22-23.9	24-25.9	26-27.9	28-29.9
12-12.9	3	1				1				
13-13.9	5		1	2	2	1				
14-14.9	6	2	1	2	5	4	2			
15-15.9	8		2	1	1	2				
16-16.9	4	10	1	4	6	8				
17-17.9	2	9	2	5	4	14	4			
18-18.9	2	4	3	3	8	17	1			
19-19.9		4	1	2	11	14	1	1		
20-20.9		1		2	10	14	2			
21-21.9					10	19	2	1	1	
22-22.9				1	25	38	4	7	1	
23-23.9		1		1	27	26	7	9		
24-24.9				1	17	22	9	6	1	
25-25.9					11	5	6	10		
26-26.9					8	11	5	10		1
27-27.9					2	6	6	9	1	
28-28.9					1	3	7	9	1	
29-29.9					2	2	3	11		
30-30.9					1		6	7		
31-31.9							3	7	2	
32-32.9					1	1		4		
33-33.9								6		2
34-34.9								5	2	
35-35.9								5		3
36-36.9								4		2
37-37.9								2	1	
38-38.9								6		3
39-39.9								1		
40-40.9								1		2
41-41.9								2		
42-42.9								2		1
43-43.9										2
44-44.9										
45-45.9										1
46-46.9										1
47-47.9										
48-48.9										
49-49.9										
50-50.0										
51-51.9										1
TOTALS	30	32	11	24	153	208	68	125	10	19

Figure 1. An example of a sample tree distribution (Pinus caribaea, 2.4 x 2.4 m spacing, Beerburrum Sub-district

Total Height Volume Equations

Total height volume equations of the form:

$$V = a + bA + cT + dAT \quad (4)$$

where T is total height,

are useful for determining volume in stands where radical management regimes, such as extremes of thinning and initial spacing, have been imposed. They also yield more precise estimates of volumes than predominant height volume equation, especially for small samples. These equations are used for research use only, as the cost of measuring individual height prohibits their routine use.

Equations of the form (1) and (4) above may yield negative estimates of volumes for small stems (Vanclay 1980). Equations of the form:

$$V = A + bAT \quad (5)$$

and

$$V = bAT \quad (6)$$

have been produced to determine the total volume of small stems of major plantation species. These equations are employed for early assessment of tree breeding and silvicultural trials. The estimated volumes should not be compared directly with volumes determined from (1) and (4) above.

Merchantable Height Volume Equations

These equations have been computed for some major plantation species to determine the volume to a specified height. They are linear functions in predominant height, basal area breast high over bark and merchantable height, and are used infrequently for various purposes.

Small End Diameter Volume Equations

Small end diameter volume equations are used by the New Zealand Forest Service and British Forestry Commission (Hamilton 1975, page 24).

Similar equations have been compiled for the convenience of sawmillers in Queensland, for various plantation species. Because small end diameter is not as well correlated with volume as is DBHOB or large end diameter, these equations are less accurate than the conventional predominant and total height volume equations. However, if only the small end diameter and log length are known, these equations provide a useful indication of log volume.

Accuracy can be improved by the incorporation of predominant height into the equations. This is a feasible procedure because the average predominant height is known for practically all stands in which commercial logging operations are carried out. Even with the predominant height included, accuracy still does not approach that of the conventional equations.

EQUATION DESCRIPTIONS

The notation used in this compendium is described in Appendix 1 and the equations themselves are shown in Appendix 2.

ACKNOWLEDGEMENTS

The sample trees on which these volume equations have been based, were measured by numerous officers of the Department over many years.

The volume equations reported in Appendix 1 have been derived by Messrs R.D. Beck, N.B. Henry, and the authors as part of the research program of the Division of Technical Services, Queensland Department of Forestry.

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APPENDIX 1

Volume Table Notation

A six digit code was assigned to each volume equation for rapid identification and as an access key in computer systems. However, with the increase in the numbers and types of volume equations, the systems which use them, and the desirability of standardization throughout the Department, it has become necessary to restructure the volume table code. The new code of 13 characters, adopted in late 1982, contains 4 elements:

SSSSHHHHHLLYY

where

SSSS is the species code

HHHHH is the equation code

LL is the location code

YY is the year of compilation

Species Code (SSSS)

The four digit code, which was originally developed for the processing rainforest experiments and detailed yield plots, has since been expanded to cover all trees of interest to the Department. It is now used for many purposes and is virtually the standard Departmental species code, even though it is still commonly referred to as the 'DYP code'. Volume equations are available for the following species:

Botanical Name	Species Code
Araucaria cunninghamii	0096
Araucaria bidwillii	0335
Flindersia brayleyana	0055
Pinus elliottii var. *elliottii*	1126
Pinus caribaea var. *hondurensis*	1115
Pinus taeda	1121
Pinus patula	1123
Pinus radiata	1124
Pinus kesiya	1112
Pinus palustris	1122
Pinus roxburghii	1299
Agathis robusta	0592
Eucalyptus grandis	0394

Equation Code (HHHHH)

The equation code comprises three elements; two characters and three digits in the form:

HL999

H is the height parameter used in the equation, either 'P' for predominant height of 'T' for total height equations. L describes the limit used in the equation and takes values of 'D', 'H' and 'B'. D is used when the volume is calculated to a small end diameter underbark, H when it is calculated to a height limit above the ground, and B for equations which calculate the volume between 7 cm t.d.u.b. and a larger diameter underbark.

The digits show the numerical value of the limit used. Thus, PD070 refers to a predominant equation volume equation to a 7 cm t.d.u.b. Height limits are shown in decimetres, hence a pruned height of 6.4 m will code as PH064.

Location Code (LL)

The two digit Sub-district codes used in the Department's accounting system were adopted and are used to identify equations which apply over limited regions. An identifying Sub-District is allocated when the applicable range of the equation extends over more than one Sub-district. The code 00 is used when the equation applies to a species throughout its range.

The codes are as follows:

	Sub-district	
District	**Code**	**Name**
Queensland	00	
North Queensland	01	Atherton
	02	Ingham
Brisbane	03	Beerburrum
	04	Brisbane
Dalby	05	Chinchilla
	06	Dalby
	07	Roma
Gympie	08	Gympie
	09	Imbil
	10	Toolara
Rockhampton	11	Mackay
	12	Rockhampton
Maryborough	13	Bundaberg
	14	Fraser Island
	18	Tuan
Monto	17	Monto
	16	Kalpowar
Murgon	19	Jimna
	20	Murgon
Warwick	21	Inglewood
	22	Warwick
Yarraman	23	Benarkin
	24	Yarraman

The Superseded Code

The superseded 6 digit code is included in brackets for each equation in the compendium, to enable identification from older documents.

Other Notation

V_T = total stem volume, including stump volume,

V_P = pruned section volume, excluding 15 cm stump,

V_N = merchantable volume to n cm t.d.u.b. (n = 7, 10, 12 or 15) excluding 15 cm stump,

A = sectional area breast high over bark (sq m),

H = average predominant height (m),

T = total height (m),

L = merchantable height (m) above ground, and

D = small end diameter, under bark (cm)

APPENDIX 2

The Compendium of Equations

ARAUCARIA CUNNINGHAMII

COASTAL AREAS (IMBIL) (Sample Size 2675)

Predominant Height

0096PD0000973 (010173) $V_T = 0.024520 + 0.72262A - 0.0035530H + 0.38830AH$

0096PD0700973 (010273) $V_7 = 0.018587 + 0.67542A - 0.0036325H + 0.38726AH$

0096PD1000973 (010373) $V_{10} = 0.010388 + 0.67542A - 0.0036325H + 0.38726AH + 0.000015037/A - 0.0000095219H/A$

0096PD1200973 (011373) $V_{12} = 0.006587 + 0.67542A - 0.0036325H + 0.38726AH + 0.0000375/A - 0.000024H/A$

0096PD1500973 (010473) $V_{15} = -0.0042820 + 0.67542A - 0.0036325H + 0.38726AH + 0.00011025/A\ 0.000092423H/A$

0096PB1500973 (010673) $V_{7-15} = 0.022869 - 0.00011025/A + 0.000092423H/A$

0096PH0670973 (010573) $V_P = -0.022788 + 4.38503A + 0.00066297H + 0.029948AH$

0096PH1080973 (010965) $V_{P10.8} = 0.04350 + 4.82831A + 0.0013332H + 0.09865AH$

Total Height

0096TD0000973 (012173) $V_T = -0.015088 - 1.79465A + 0.0025200T + 0.44261AT$

0096TD0700973 (012273) $V_7 = -0.021277 - 1.76271A + 0.002363T + 0.43971AT$

0096TD1000973 (012373) $V_{10} = -0.37479 - 1.28212A + 0.0018982T + 0.43120AT$

0096TD1500973 (012473) $V_{15} = -0.16598 + 1.44342A + 0.0024598T + 0.36481AT$

0096TH0670973 (012573) $V_P = -0.029611 + 3.91920A + 0.0019231T + 0.035774AT$

A. CUNNINGHAMII

INLAND AREAS (Sample Size 2548)

(YARRAMAN)

Predominant Height

0096PD0002472 V_T = 0.040124 - 1.00641A - 0.0035051H + 0.43232AH
(020172)

0096PD0702472 V_7 = 0.034816 - 1.08267A - 0.0036109H + 0.43275AH
(020272)

0096PD1002472 V_{10} = 0.0275814 - 1.08267A - 0.0036109H + 0.43275AH + 0.0000096576/A - 0.00001040H/A
(020372)

0096PD1202472 V_{12} = 0.021197 - 1.08267A - 0.0036109H + 0.43275AH + 0.000013313/A - 0.000027480H/A
(021372)

0096PD1502472 V_{15} = 0.015303 - 1.08267A - 0.0036109H + 0.43275AH + 0.00014209/A - 0.00010071H/A
(020472)

0096PB1502472 V_{7-15} = 0.019513 - 0.00014209/A + 0.00010071H/A
(020672)

0096PH0672472 V_P = -0.013428 + 3.36268A + 0.00047103H + 0.062894AH
(020572)

Total Height

0096TD0002472 V_T = 0.011234 - 3.29225A + 0.0014796T + 0.50291AT
(022172)

0096TD0702472 V_7 = 0.0043657 - 3.25062A + 0.0013762T + 0.49912AT
(022272)

0096TD1002472 V_{10} = -0.012403 - 2.79616A + 0.0010014T + 0.48985AT
(022372)

0096TD1502472 V_{15} = -0.10844 - 0.37822A + 0.00012924T + 0.43285AT
(022472)

0096TH0672472 V_P = -0.017159 + 2.72560A + 0.0016934T + 0.079155AT
(022572)

P. CARIBAEA VAR. *HONDURENSIS* (Sample Size 807)

Predominant Height

1115PD0000074 V_T = $0.066154 - 1.61772A - 0.0041728H + 0.37856AH$
(050174)

1115PD0700074 V_7 = $0.057257 - 1.58434A - 0.0041199H + 0.37490AH$
(050274)

1115PD1000074 V_{10} = $0.053684 - 1.58434A - 0.0041199H + 0.37490AH + 0.000046020/A - 0.000022870H/A$
(050374)

1115PD1200074 V_{12} = $0.049934 - 1.58434A - 0.0041199H + 0.37490AH + 0.000071906/A - 0.000054397H/A$
(051374)

1115PD15000074 V_{15} = $0.053144 - 1.58434A - 0.0041199H + 0.37490AH - 0.00022600/A - 0.0001545H/A$
(050474)

1115PB1500074 V_{7-15} = $0.0041131 + 0.00022600/A + 0.00015451H/A$
(050674)

1115PH0670074 V_P = $0.013325 + 2.26779A - 0.00071320H + 0.066774AH$
(050574)

Total Height

1115TD0000074 V_T = $0.028558 - 2.65295A + 0.00015006T + 0.41133AT$
(052174)

1115TD0700074 V_7 = $0.020109 - 2.60804A + 0.00015633T + 0.40731AT$
(052274)

1115TD1000074 V_{10} = $-0.0027275 - 2.23637A + 0.00016867T + 0.39818AT$
(052374)

1115TD1500074 V_{15} = $-0.14246 + 0.23813A + 0.00091681T + 0.33297AT$
(052474)

1115TH0670074 V_P = $0.0050586 + 1.96468A + 0.00027110T + 0.075825AT$
(052574)

PINUS ELLIOTTII VAR. *ELLIOTTII*

COASTAL AREAS (Sample Size 1125)

(BEERBURRUM)

Predominant Height

1126PD0000373 V_T = $-0.015937 + 1.35943A - 0.0020161H + 0.33741AH$
(030173)

1126PD0700373 V_7 = $-0.021301 + 1.39645A - 0.0021668H + 0.33478AH$
(030273)

1126PD1000373 V_{10} = $-0.021301 + 1.39645A - 0.0021668H + 0.33478AH + 0.000010961/(A - 0.001) - 0.000022548H/(A - 0.001)$
(030373)

1126PD1200373 V_{12} = $-0.021301 + 1.39645A - 0.0021668H + 0.33478AH - 0.00008495/(A - 0.003) - 0.00006809H/(A - 0.003)$
(031373)

1126PD1500373 V_{15} = $-0.021301 + 1.39645A - 0.0021668H + 0.33478AH - 0.00022811/(A - 0.003) - 0.00013786H/(A - 0.003)$
(030473)

1126PB1500373 V_{7-15} = $0.00022811/(A - 0.003) + 0.00013786H/(A - 0.003)$
(030673)

1126PH0670373 V_P = $-0.014155 + 3.83463A + 0.028648AH$
(030573)

Total Height

1126TD0000373 V_T = $-0.013452 - 0.19897A + 0.00021398T + 0.38866AT$
(032173)

1126TD0700373 V_7 = $-0.022036 - 0.049203A + 0.00015538T + 0.38164AT$
(032273)

1126TD100373 V_{10} = $-0.052613 + 0.90635A + 0.00012324T + 0.35483AT$
(032373)

1126TD1500373 V_{15} = $-0.30733 + 8.91924A + 0.0019749T + 0.11680AT$
(032473)

1126TH0670373 V_P = $-0.032840 + 3.99383A + 0.0013423T + 0.016250AT$
(032573)

P. ELLIOTTII* VAR. *ELLIOTTII

INLAND AREAS (Sample Size 450)

(WARWICK)

Predominant Height

1126PD0002281 V_T = (100181)	0.11690 - 0.69048A - 0.0081213H + 0.42994AH
1126PD0702281 V_7 = (100281)	0.055776 - 0.97875A - 0.0060310H + 0.43755AH
1126PD1002281 V_{10} = (100381)	0.052663 - 0.97875A - 0.0060310H + 0.43755AH - 0.0000032961/(A - 0.003) - 0.000013766H/(A - 0.003)
1126PD1202281 V_{12} = (101381)	0.050864 - 0.97875A - 0.0060310H + 0.43755AH - 0.000069438/(A - 0.005) - 0.000030730H/(A - 0.005)
1126PD1502281 V_{15} = (100481)	0.052265 - 0.97875A - 0.0060310H + 0.43755AH - 0.000074607/(A - 0.005) - 0.00011315H/(A - 0.005)
1126PB1502281 V_{7-15} = (100681)	0.0035110 + 0.000074607/(A - 0.005) + 0.00011315H/(A - 0.005)
1126PH0672281 V_P = (100581)	-0.028945 + 3.45230A + 0.0012907H + 0.042671AH

Total Height

1126TD0002281 V_T = (102181)	-0.035930 - 1.44560A + 0.0068484T + 0.41895AT
1126TD0702281 V_7 = (102281)	-0.049100 - 1.16780A + 0.0044083T + 0.41689AT
1126TD1002281 V_{10} = (102381)	-0.068799 - 0.95443A + 0.0047458T + 0.40957AT
1126TD1502281 V_{15} = (102481)	-0.19337 - 0.090196A + 0.0089010T + 0.37567AT
1126TH0672281 V_P = (102581)	-0.044395 + 3.38440A + 0.0031022T + 0.039830AT

P. PATULA (Sample Size 899)

Predominant Height

1123PD0000082 V_T = (080182)	-0.0103603 + 0.396238AH
1123PH0670082 V_P = (080582)	-0.023282 + 3.57841A + 0.0015338H + 0.041179AH
1123PD0700082 V_7 = (080282)	-0.016480 + 0.391344AH
1123PD1000082 V_{10} = (080382)	-0.018392 + 0.39134AH + 0.000049985/ (A- 0.003) - 0.000017165H/(A- 0.003)
1123PD1200082 V_{12} = (081382)	-0.017634 + 0.39134AH + 0.00019014/ (A - 0.003) - 0.000053789H/(A - 0.003)
1123PD1500082 V_{15} = (080482)	-0.014922 + 0.39134AH + 0.00026712/ (A - 0.005) - 0.00014046H/(A - 0.005)
1123PD2000082 V_{20} = (081482)	0.0014370 + 0.39134AH - 0.0012773/ (A - 0.009) - 0.00040754H/(A - 0.009)
1123PD2500082 V_{25} = (081582)	0.055838 + 0.39134AH - 0.0099465/A - 0.0011051H/A
1123PB1000082 V_{7-10} = (081082)	0.0019115 - 0.000049985/(A - 0.003) + 0.000017165/(A - 0.003)
1123PB1200082 V_{7-12} = (081182)	0.0011537 - 0.00019014/(A - 0.003) + 0.000053789H/(A - 0.003)
1123PB1500082 V_{7-15} = (080682)	-0.0015584 - 0.00026712/(A - 0.005) + 0.00014046H/(A - 0.005)
1123PB2000082 V_{7-20} = (081682)	-0.017917 + 0.0012773/(A - 0.009) +0.00040754H/(A - 0.009)
1123PB2500082 V_{7-25} = (081782)	-0.072318 + 0.0099465/A + 0.0011051H/A

Total Height

1123TD0000082 V_T = (082182)	-0.37585 - 1.11051A - 0.0037408T + 0.44819AT
1123TH0670082 V_P = (082582)	-0.026382 + 3.40553A + 0.0021807T + 0.048064AT
1123TD0700082 V_7 = (082282)	-0.045554 - 1.11309A + 0.0038806T + 0.44381AT

1123TD1000082 (082382)	V_{10} =	-0.070038 - 0.82074A + 0.0044487T + 0.43218AT
1123TD2500082 (082482)	V_{15} =	-0.23883 + 0.95681A + 0.0094776T + 0.36458AT
1123TD2000082 (082782)	V_{20} =	-0.544416 + 3.039034A + 0.017631T + 0.29357AT
1123TD2500082 (082882)	V_{25} =	-0.76860 + 4.37660A + 0.014992T + 0.28066AT

P. RADIATA (EXCLUDING GAMBUBAL) (Sample Size 587)

Predominant Height

1124PD0000082 (060182) $V_T = -0.024781 + 2.47815A + 0.00060303H + 0.21397AH$

1124PD0700082 (060282) $V_7 = -0.030691 + 2.43891A + 0.00046935H + 0.21182AH$

1124PD1000082 (060382) $V_{10} = -0.035622 + 2.43891A + 0.00046935H + 0.21182AH + 0.0001285/A - 0.000022443H/A$

1124PD1200082 (061283) $V_{12} = -0.039951 + 2.43891A + 0.00046935H + 0.21182AH + 0.00028434/A - 0.000054451H/A$

1124PD1500082 (060482) $V_{15} = -0.044813 + 2.43891A + 0.00046935H + 0.21182AH + 0.0010575/A - 0.00017340H/A$

1124PD2000082 (061482) $V_{20} = -0.060402 + 2.43891A + 0.00046935H + 0.21182AH + 0.0058439/A - 0.00067424H/A$

1124PD2500082 (061582) $V_{25} = -0.07803 + 2.43891A + 0.00046935H + 0.21182AH + 0.018274/(A - 0.003) - 0.0018660H/(A - 0.003)$

1124PB1000082 (061082) $V_{7-10} = 0.00493156 - 0.00012845/A + 0.000022443H/A$

1124PB1200082 (061182) $V_{7-12} = 0.0092605 - 0.00028434/A + 0.000054451H/A$

1124PB1500082 (060682) $V_{7-15} = 0.014122 - 0.0010575/A + 0.00017340H/A$

1124PB2000082 (062982) $V_{7-20} = 0.029711 - 0.0058439/A + 0.00067424H/A$

1124PB2500082 (063082) $V_{7-25} = 0.047334 - 0.018274/(A - 0.003) + 0.0018660H/(A - 0.003)$

Total Height

1124TD0000082 (062182) $V_T = 0.0013045 - 1.51255A + 0.0027483T + 0.36371AT$

1124TD0700082 (062282) $V_7 = -0.0058840 - 1.55510A + 0.0026865T + 0.36133AT$

1124TD1000082 (062382) $V_{10} = -0.020777 - 1.38270A + 0.0024905T + 0.35688AT$

1124TD1500082 V_{15} = −0.082506 − 0.79877A + 0.0018129T + 0.34369AT
(062482)

1124TD2000082 V_{20} = −0.18716 − 0.20649A + 0.00010336T + 0.33577AT
(062782)

1124TD2500082 V_{25} = −0.43382 + 0.348457A + 0.0028085T + 0.32414AT
(062882)

P. TAEDA

COASTAL AREAS (Sample Size 1043)

(BEERBURRUM)

Predominant Height

1121PD0000373 (040173) $V_T = -0.011329 + 1.04582A - 0.0011153H + 0.34722AH$

1121PD0700373 (040273) $V_7 = -0.015708 + 1.07671A - 0.0013043H + 0.34458AH$

1121PD1000373 (040373) $V_{10} = -0.015708 + 1.07671A - 0.0013043H + 0.34458AH + 0.000076254/A - 0.000025078H/A$

1121PD1200373 (041373) $V_{12} = -0.015708 + 1.07671A - 0.0013043H + 0.34458AH + 0.0001686/(A - 0.005) - 0.00006473H/(A - 0.005)$

1121PD1500373 (040473) $V_{15} = -0.015708 + 1.07671A - 0.0013043H + 0.34458AH + 0.00031946/(A - 0.005) - 0.00012824H/(A - 0.005)$

1121PB1000373 (041073) $V_{7-10} = -0.000076254/A + 0.000025078H/A$

1121PB1500373 (040673) $V_{7-15} = -0.00031946/(A - 0.005) + 0.00012824H/(A - 0.005)$

1121PB0640373 (040573) $V_P = -0.029621 + 4.27031A + 0.0011488H + 0.0078303AH$

Total Height

1121TD0000373 (042173) $V_T = -0.012912 + 0.010700A + 0.00079288T + 0.38477AT$

1121TD0700373 (042273) $V_7 = -0.019285 + 0.13219A + 0.00064205T + 0.37855AT$

1121TD1000373 (042373) $V_{10} = -0.041595 + 1.05528A + 0.00026664T + 0.35307AT$

1121TD1500373 (042473) $V_{15} = -0.17585 + 4.99675A + 0.00022135T + 0.24058AT$

1121TH0640373 (042573) $V_P = -0.028383 + 4.03789A + 0.0014923T + 0.013616AT$

P. TAEDA

INLAND AREAS (Sample Size 233)

(WARWICK)

Predominant Height

1121PD0002281 V_T = 0.079760 - 0.67260A - 0.0087666H + 0.46874AH
(110181)

1121PD0702281 V_7 = 0.075306 - 0.71476A - 0.0088490H + 0.46394AH
(110281)

1121PD1002281 V_{10} = 0.071821 - 0.71476A - 0.0088490H + 0.46394AH + 0.000053373/(A - 0.003) - 0.000016234H/(A - 0.003)
(110381)

1121PD1202281 V_{12} = 0.068531 - 0.71476A - 0.0088490H + 0.46394AH + 0.000081774/(A - 0.005) - 0.000034951H/(A - 0.005)
(111381)

1121PD1502281 V_{15} = 0.065823 - 0.71476A - 0.0088490H + 0.46394AH + 0.000052668/(A - 0.005) - 0.000098005H/(A - 0.005)
(110481)

1121PB1502281 V_{7-15} = 0.0094833 - 0.000052668/(A - 0.005) + 0.000098005H/(A - 0.005)
(110681)

1121PH0642281 V_P = 0.013170 + 1.97930A - 0.0011716H + 0.12302AH
(110581)

Total Height

1121TD0002281 V_T = 0.050406 - 1.9463A - 0.0039837T + 0.50535AT
(112181)

1121TD0702281 V_7 = 0.045883 - 1.96940A - 0.0041160T + 0.50000AT
(112281)

1121TD1002281 V_{10} = 0.029380 - 1.57010A - 0.0041419T +0.48466AT
(112381)

1121TD1502281 V_{15} = -0.020049 - 0.32677A - 0.0060245T + 0.44705AT
(112481)

1121TH0642281 V_P = -0.0060024 + 2.77900A + 0.000091715T + 0.081627AT
(112581)

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