RESEARCH NOTE

DEPARTMENT OF FORESTRY
QUEENSLAND

SMALL   TREE   STEM   VOLUME   EQUATIONS   FOR

THREE   PLANTATION   SPECIES

BY

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SUMMARY

Volume equations are given for small hoop pine (*Araucaria cunninghamii* Ait. ex D. Don), Caribbean pine (*Pinus caribaea* Mor. var. *hondurensis* Barr. and Golf) and slash pine (*Pinus elliottii* Engelm. var. *elliottii*) trees.

INTRODUCTION

The standard volume equations used by the Queensland Department of Forestry are based on sample trees with diameter at breast height over bark (d.b.h.o.b.) greater than 12 cm and predominant height greater than 10 m. The equations are of the form:

$$\text{Volume} = a + bA + cH + dAH \tag{1}$$

where A = basal area breast high over bark (sq m)

H = predominant height (m)

(mean height of 50 tallest trees per hectare)

a, b, c, d constants

A set of such equations is available for each major species, giving total stem volume under bark and volume above stump to various top diameters. These equations give reliable estimates of volume for stems of merchantable size and are suitable for both research use and for the sale of merchantable timber.

Additional equations have been prepared using the total height of individual trees as a regressor variable, rather than stand predominant height. These are intended for research use, particularly where wide treatment differences exist.

However, there is an increasing need to provide precise estimates of the volume of very small stems, to allow early appraisal of a wide range of experiments covering genetics, nutrition and silviculture. The standard volume equations may be unsatisfactory for those small sizes which were deliberately excluded from the data used to construct these equations. Comparison of actual sample tree measurements with current total height volume equations revealed significant bias in estimates of total volume for trees with total height less than 12 m.

This paper outlines the development of equations suitable for the assessment of volumes of small trees of the three major taxa planted in Queensland.

METHODS

Sample trees with predominant heights less than 15 m were selected from the sample tree library. This set was supplemented with special collections of sample trees to ensure adequate sampling over a wide range of sizes and locations. The size distribution of sample trees is given in Appendix 1. Predominant height was selected as the criterion to exclude small senescent trees in taller stands (particularly in hoop pine) which may have different form.

Total stem volume under bark was calculated using Newton's formula (Alemdag 1978) where end and centre diameters of the section were known. In other cases convex parabolic and concave hyperbolic integrals (Grosenbaugh 1966) were used.

Samples from different locations were grouped as no geographic variation in stem form was observed.

A cylindrical form factor was chosen for its simplicity and stability. Regression analysis revealed that this adequately described the data, except for hoop pine, where an intercept was significant.

RESULTS AND DISCUSSION

The results of regression analysis are summarised in Table 1. Total stem volume of these small trees is best predicted by:

$$V = a + b AH \qquad (2)$$

where V = total stem volume under bark (cu m)

A = basal area breast high over bark (sq m)

H = total height of tree (m)

a, b constants, values given in Table 1.

These equations should be applied only to trees with:

. predominant height less than 15 m;

. total height less than 18 m;

. d.b.h.o.b. less than 25 cm.

Within this range, the 1 per cent confidence limits for a single observation are less than 0.0002 cu m. Actual confidence limits may be calculated using the equation and data given in Appendix 2.

Table 1. Coefficients of regression

Species	a	b	r^2	Number of trees
Hoop pine	0.0043210	0.34623	0.98	1003
Caribbean pine	0.0	0.30151	0.98	207
Slash pine	0.0	0.35135	0.97	750
Loblolly	0-0	0.37686	0-93	334

ACKNOWLEDGEMENTS

REFERENCES

Alemdag, I.S. (1978). An analytical look at the Log Volume Formulas. Forest Management Institute, Canadian Forest Service, April, 1978: 17 pp.

Grosenbaugh, L.R. (1966). Tree Form: Definition, interpolation, extrapolation. *Forestry Chronicle* 42 (4): 444-457.

Appendix 1.   Distribution of sample trees

D.b.h.o.b. (cm)	Total height (m)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
(a) Hoop pine																	
1																	
2																	
3																	
4																	
5																	
6				1	7												
7				1	2	6											
8						8	15	11	5								
9						1	25	29	17	3							
10						2	8	24	22	17	2						
11							2	24	27	38	11	10					
12							2	10	42	50	35	17	5				
13									9	24	30	33	10	2			
14								1	4	11	23	52	14	4			
15									1	2	30	34	21	6	3		
16										3	4	18	21	20	4	1	
17										3	7	20	22	4	1		
18											4	9	18	6	4		1
19											1	2	8	4	4	2	
20													2	4	1		
21													3	2		1	
22														1		2	
23															1		
24													1				
(b) Caribbean pine																	
1																	
2																	
3																	
4		1	1														
5			9	1	1												
6			6	5	1												
7			2	1	1												
8				1	3	1		1									
9					1	2	2										
10						2	6	1									
11						4	8	1		1							
12						1	4	5	3	3	3	1					
13								5	4	2	3	3	1				
14								1	4	1	5	2					
15									5	7	7	3	1				
16									4	2	7	7	2				
17									1	3	4	9	2	1			
18										2	6	3	5	1			
19											1	3		1			
20											1		1				
21														2			
22														1			
23													1				

Appendix 1 (cont.)

D.b.h.o.b. (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
						(c)	Slash pine							
1														
2														
3														
4														
5														
6			4	7	2	1	1							
7				9	4	1	1							
8				8	11	4	1	3						
9					4	8	7							
10						10	7	3						
11					4	5	11	7	7	1				
12						3	3	16	18	6	3			
13							1	19	17	18	9	1		
14							2	6	17	27	17	7		
15								2	19	27	25	13	3	
16								2	18	18	32	10	1	
17									7	16	26	15	5	
18								1	6	16	17	20	14	
19										5	17	16	10	2
20										3	10	9	7	3
21										2	6	2	1	2
22												3	2	3
23												2	2	1
24											1		1	
25													1	
26														1
27														

Loblolly absolute range: DBHOB 11 — 23 cm

Tot Ht 9 — 15 m

Appendix 2.   Calculation of confidence limits

Confidence limits for single observation may be calculated using the following formula:

$$CL = tS \sqrt{1 + 1/n + C_{11} (\bar{x} - x)^2}$$

where x is desired AH (cu m)

t is Student's t for (n − 2) d.f.

and

	n	S	C_{11}	$\bar{x}$
Hoop pine	1003	0.000027270	0.088059	0.16571
Caribbean pine	207	0.000029797	0.107591	0.17484
Slash pine	750	0.000049519	0.022052	0.21308
Loblolly pine	334	0.0000 62711	0.036824	0.27346