JAS log volume estimates of New Zealand radiata pine and Douglas-fir logs

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Abstract

Sectionally measured radiata pine and Douglas-fir sawlog data has been analysed to study the relationship between true volume and that derived using the Japanese Agricultural Standard (JAS). Although JAS volume estimates on logs of average dimensions are close to true cubic, large errors are introduced with increase in log taper and decrease in small-end diameter.

Introduction

Softwood logs exported from New Zealand are almost all sold on volume based on the Japanese Agricultural Standard (JAS). This scale, now in metric, has been in use since 1945 (Zumwalt, 1946). Within New Zealand, logs have historically been sold on underbark volume, although some local board rules were used to a limited extent (Duff, 1954). The NZ forest industry is used to being paid on true cubic content. There is no fixed relationship between JAS and cubic metres and this has caused distrust amongst those being paid on the basis of JAS cubic metres. In 1993 the Canterbury Sawmillers Association published a notice in the local paper (The Christchurch Press, February 13, 1993) warning those intending to sell logs on the basis of JAS cubic metres.

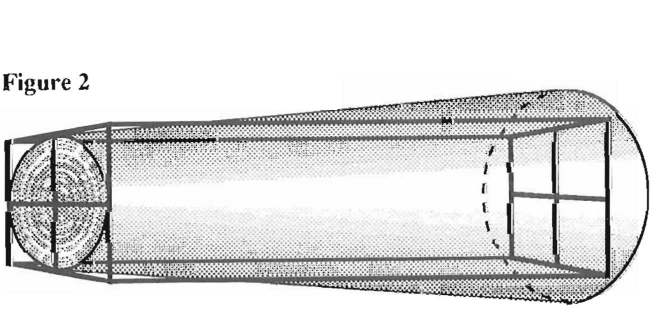
This study was undertaken to provide average conversion values between JAS and cubic metres for logs covering a range of small-end diameters, length and taper.

It is normal practice for individual forestry companies to compile and use their own conversion values to relate volume in JAS to NZ cubic metres and vice versa. The conversion values are used to relate JAS to true cubic metres for stand reconciliation, contract payment and log purchasing and selling.

Scaling for JAS

Volume in JAS is derived from two formulae, one for logs of less than 6.0 metres in length and the other for logs of 6.0 metres and longer, (Ellis 1994). For short logs with little eccentricity, volume is that of a rectangular solid based on the shortest diameter through the sawn small-end of the log of the same length as shown in Figure 2.

Figure 2

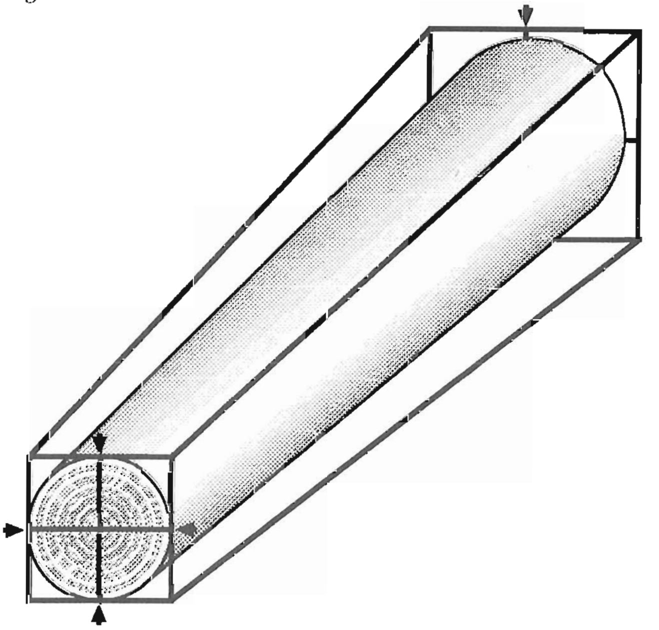


The portion of the rectangle at the small-end falling outside the log is considered to be equal to the taper portion of the log outside the rectangle, further along the log.

For long logs, the JAS formula has a taper allowance and it is possible for the rectangular solid (represented by the JAS formula) to be outside the round of the log for its whole length

Figure 1 The JAS volume of this load of logs is about 30% less than true cubic.

Figure 3



(Figure 3), although it is more usual to include part of the larger end of the log.

Diameters at the small-end are rounded down to the nearest even centimetre (single centimetres for diameters below 14 cm) and based on the shortest axis unless there is a difference of at least 6 cm between short and long axis. If the shortest axis is 40 cm or larger, two centimetres are added for every 8 cm difference between shortest and longest diameter. Lengths of 3.0 m and above are rounded down to the nearest 0.2 m except for the lengths 3.3 m, 3.65 m and 4.3 m which fit in between the normal classes (Kuchimura, 1989).

Basic data

In the 25 years prior to 1983 the New Zealand Forest Service used

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volume tables based on small-end diameter (underbark) and length to estimate the volume of logs removed from state exotic forests. Each species/locality had a separate table once logging commenced. The total number of tables produced was about 400 with up to 100 in use at any one time. Tables were tested and more often than not updated within five years of issue.

The basic data for each "approved" log volume table comprised at least 200 logs. Each of them was sectionally measured for volume. This was based on diameters measured with girth-tape at butt, 1.5 metres (5 feet), 3.0 metres (10 feet), 6.0 metres (20 feet) and so on from the butt, and at the small end so that no section exceeded 3 metres (10 feet) in length. Smalian's formula was then applied to each section.

Many thousands of sectionally measured logs were accumulated but for this study only the data of radiata pine and Douglas-fir are used. The full range of data is shown by small-end diameter (sed), length and taper in Table 1 and Table 2.

Table 1

Logs	38574		
	min	mean	max
sed (cm)	4.8	25.5	88.4
length (m)	2.4	7.9	18.0
taper (cm/m)	0.0	1.09	9.5

Table 1 Radiata pine

Table 2

Logs	5733		
	min	mean	max
sed (cm)	5.8	20.0	66.5
length (m)	2.4	8.4	15.4
taper (cm/m)	0.1	1.10	5.2

Table 2 Douglas -fir

Table 3

length class (m)	small-end diameter class (cm)			
	10-20	20-30	30-40	ALL
3.0 - 5.9	3106	5841	3066	12013
6.0 - 8.9	2638	3416	1494	7548
9.0 - 11.9	3191	3904	2090	9185
ALL	8935	13161	6650	28746

Table 3 Number of radiata pine logs by diameter and length

Table 4

length class (m)	small-end diameter class (cm)			
	10-20	20-30	30-40	ALL
3.0 - 5.9	692	549	210	1451
6.0 - 8.9	553	291	81	925
9.0 - 11.9	1643	713	108	2464
ALL	2888	1553	399	4840

Table 4 Number of Douglas-fir logs by diameter and length

From the above range of data only those data which represented the normal extremes in log dimensions were used. Tables 3 and 4 show the number of logs by length and small-end diameter for radiata pine and Douglas-fir that are used in this study.

Basic data used to calculate the conversions were principally collected from domestic sawlogs rather than export logs. The large amount of data adequately covers the lengths and small-end diameters common in current sawlogs. Many of the log measurements were from "old crop", not young-crop stands. It is thought that the use of taper classes should adequately represent logs from young-crop stands. The present log distribution of sed, length and taper fits into the 0.8-1.19 cm/m taper class for the varying small-end diameter and length classes required for export grades.

The study

A computer program was written to process the basic data and calculate sectional volumes and volumes by a variety of methods including JAS. The small-end diameters and lengths were also calculated by rounding or truncating according to the particular scaling conventions.

It should be noted that the basic data (diameter and bark thicknesses along the length of each log) were in imperial units until 1978. Such data were converted to metric using the values of 1 inch = 2.54 centimetres and 1 foot = 0.3048 metres. For further calculations the exact figures for diameter, bark thickness and length were used with no rounding.

For each log the computer program calculated small-end diameter (u.b.), actual volume, JAS volume, length and taper. These data were then written to two summary files (radiata pine and Douglas-fir) and analysed by a statistical program which calculated the bias in JAS volume for small-end diameter, length and taper classes. Bias is defined as 100* (JAS volume – cubic metres)/JAS volume.

Results

It was found that over half of the bias in JAS volume (56% radi-

Figure 4a

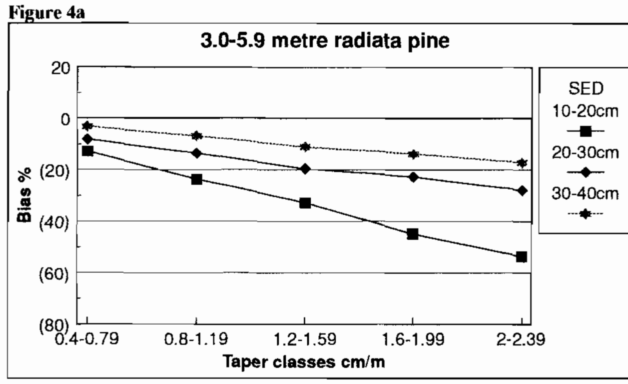


Figure 4a Bias in JAS volume on sed and taper

Figure 4b

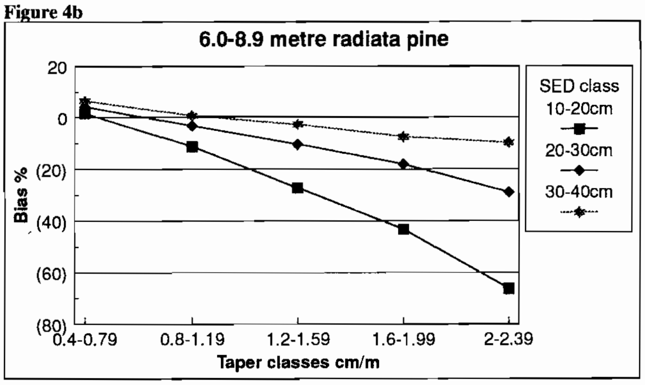


Figure 4b Bias in JAS volume on sed and taper

Figure 4c

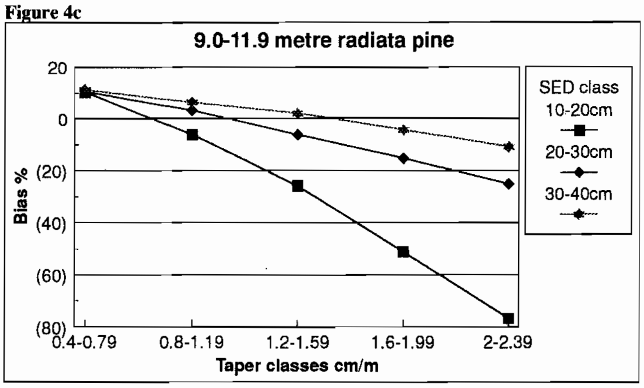


Figure 4c Bias in JAS volume on sed and taper

Figure 4d

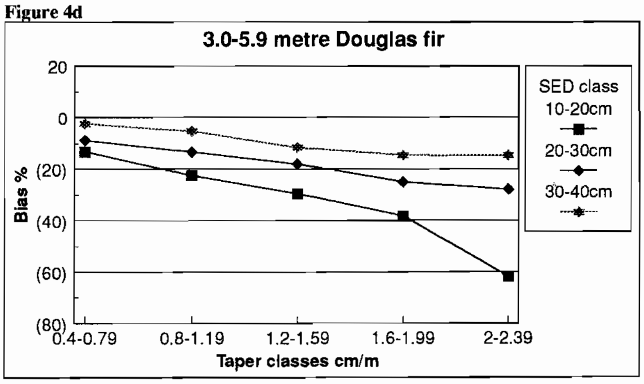


Figure 4d Bias in JAS volume on sed and taper

Figure 4e

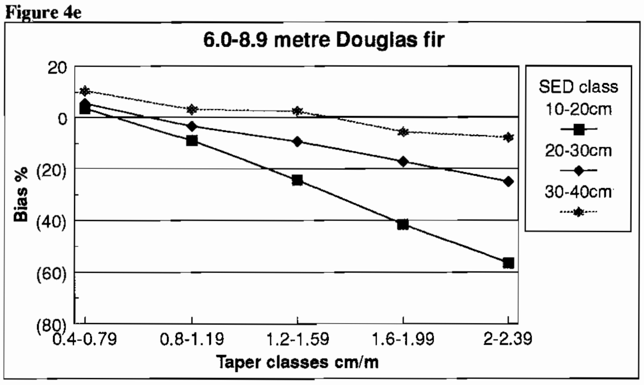
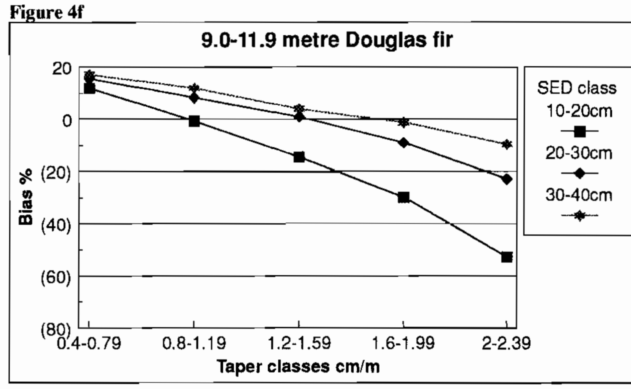


Figure 4e Bias in JAS volume on sed and taper

Figure 4f



ata pine, 62% Douglas-fir) could be accounted for by changes in sed, taper and length. Figures 4a to 4f show the bias in percent between JAS volume and true volume plotted on taper and sed for each length class.

The greatest change in bias is due to changès in taper, followed by sed and then length. The figures show that the bias increases from +10% (for 0.4 - 0.79 cm/m taper) to -77% (2.0 - 2.39 cm/m taper) in radiata pine of 9.0 - 11.9 m length and 10 - 20 cm sed. For any taper class the change in bias on sed class is at a maximum in the 2.0 - 2.39 cm/m taper where the bias changes from -77% (10 - 20 cm) to -11% (30 - 40 cm) for radiata pine in the 9.0 - 11.9 m length class. In the maximum taper class (2.0 - 2.39 cm/m) and minimum sed class (10-20 cm) bias changes from -54% for 3.0 - 5.9 m length to -77% for 9.0 - 11.9 m length in radiata pine. The bias in Douglas-fir logs is less than that in radiata pine.

Conversion factors between cubic metres and JAS units

Conversion values were calculated from the respective JAS vol-

Table 5a

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	0.887	0.925	0.970
0.8 - 1.19	0.809	0.880	0.937
1.2 - 1.59	0.753	0.837	0.901
1.6 - 1.99	0.690	0.815	0.879
2.0 - 2.39	0.651	0.782	0.854

Table 5a Conversion from JAS to cubic metres radiata pine 3.0 – 5.9 m

Table 5b

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	1.016	1.045	1.070
0.8 - 1.19	0.899	0.969	1.007
1.2 - 1.59	0.786	0.906	0.974
1.6 - 1.99	0.698	0.847	0.930
2.0 - 2.39	0.601	0.776	0.911

Table 5b Conversion from JAS to cubic metres radiata pine 6.0 – 8.9 m

Table 5c

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	1.115	1.119	1.127
0.8 - 1.19	0.942	1.033	1.068
1.2 - 1.59	0.795	0.942	1.022
1.6 - 1.99	0.662	0.867	0.959
2.0 - 2.39	0.566	0.799	0.901

Table 5c Conversion from JAS to cubic metres radiata pine 9.0 – 11.9 m

Table 5d

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	0.883	0.919	0.977
0.8 - 1.19	0.816	0.882	0.950
1.2 - 1.59	0.772	0.848	0.896
1.6 - 1.99	0.724	0.800	0.873
2.0 - 2.39	0.617	0.782	0.872

Table 5d Conversion from JAS to cubic metres Douglas-fir 3.0 – 5.9 m

Table 5e

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	1.038	1.058	1.117
0.8 - 1.19	0.918	0.967	1.032
1.2 - 1.59	0.805	0.915	1.026
1.6 - 1.99	0.707	0.854	0.948
2.0 - 2.39	0.639	0.800	0.928

Table 5e Conversion from JAS to cubic metres Douglas-fir 6.0 – 8.9 m

Table 5f

Taper (cm/m)	small-end diameter class (cm)		
	10-20	20-30	30-40
0.4 - 0.79	1.136	1.184	1.208
0.8 - 1.19	0.994	1.089	1.136
1.2 - 1.59	0.873	1.010	1.041
1.6 - 1.99	0.770	0.917	0.988
2.0 - 2.39	0.655	0.813	0.912

Table 5f Conversion from JAS to cubic metres Douglas-fir 9.0 – 11.9 m

umes and actual volumes for each small-end diameter, length and taper class. Each conversion factor is the JAS volume divided by the actual volume. Tables 5a to f give conversions from cubic metres to JAS, which is the amount of JAS per cubic metre. To convert from JAS units to m³, the JAS volume is divided by the table value.

The precision of each table value (Table 5a to f) was calculated. The probable limit of error for each value was generally within 0.5% for radiata pine and within 1.3% for Douglas-fir. However, where there are relatively few observations such as the 10-20 cm sed in the 2.0-2.39 cm/m taper class the PLE averaged 9% and 16% for radiata pine and Douglas-fir respectively. The probable limit of error (PLE) is the confidence interval (approximately 2* standard error) of each conversion expressed as a percentage of the respective average conversion value.

Discussion

Bias in JAS volume (Figs 4a to f) and implied in the conversion values (Tables 5a to f) are from sed which is based on girth measurement. Any overestimate in diameter due to the use of the girth tape is common to sed and volume and therefore has no effect on the result. However, the JAS conventions of sed always being rounded down, and sed being based on the shortest axis, do have a direct bearing on volume.

For most of the diameter range (14 cm upwards) the JAS sed is the diameter in even centimetres. For example, a diameter 25.9 cm is recorded as 24 cm in JAS. In theory this rounded-down JAS should be 1.0 cm lower than the actual sed. In practice, sample data show the rounded-down JAS about 0.9 cm lower than the actual sed. This is because where the diameter is close to the even centimetre, the scaler identifies a 2 mm division more easily than a single millimetre.

In this study the effective JAS diameter is based on the girth tape and therefore approximates an average of shortest and longest axis of the small-end section. The difference between using JAS based on average sed and "shortest" sed was examined on an external data set of 2253 export logs measured throughout New Zealand.

Table 6 below shows the diameter and volume differences due to using a short axis instead of an average diameter.

Table 6

	Species	small-end diameter class in centimetres		
		10.0 - 19.9	20.0 - 29.9	30.0 - 39.9
Diam reduction (cm)	Radiata pine	0.41 (2.2%)	0.69 (2.7%)	0.99 (2.9%)
	Douglas fir	0.21 (1.1%)	0.49 (1.9%)	0.65 (1.9%)
Vol reduction (m3)	Radiata pine	0.009 (3.0%)	0.028 (5.2%)	0.060 (6.3%)
	Douglas fir	0.007 (2.2%)	0.026 (4.6%)	0.046 (4.8%)

Table 6 Diameter and volume reductions due to use of short axis on end section

Values in brackets give volume reduction as a percentage of average volume.

The above reductions are independent of taper and for practical purposes do not affect length. Small-end diameter and species do have an effect on the magnitude of the reduction. Volumes used in compiling the graphs (Fig. 4) and conversion values (Tab. 5) have been altered by the reductions in Table 6. Douglas-fir is more cylindrical and less tapered (for same sed and length) than radiata pine. Thus Douglas-fir has higher JAS to cubic metre conversions than radiata pine.

Acknowledgements
This work would not have been possible without the foresight of the late G. Duff who, with G.A.V. Bary, pioneered log volume tables in New Zealand for exotic conifers. The basic data were painstakingly collated and corrected by J. Penman but many New Zealand Forest Service and Forest Research Institute staff have unknowingly contributed to this work. The authors would like to thank Messrs M.O. Kimberley and A.D. Gordon for their help in setting up the statistical programs.

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C.3 JAPANESE AGRICULTURAL STANDARD (JAS) KOREAN INDUSTRIAL STANDARD (KIS)
This method involves measuring small-end diameter inside bark and length of individual logs, then reading volume off tables compiled from given formulae. The formulae were developed by the Japanese Ministry of Agriculture and Forestry. As JAS (KIS) measures cubic content (in m^3) rather than board content, there is a better correlation between this measure and the actual cubic content. A correction in the interpretation of this method has meant that measurement of small-end diameter 'through the pith' is now 'through the centre'.

C.3.1 Small-end diameter
1. FOR SMALL-END DIAMETERS LESS THAN 14 CM

Measure the shortest small-end diameter inside the bark through the centre of the log. Round down to the nearest whole centimetre. Example: 12.00 – 12.99 cm, record as 12 cm.

2. FOR SMALL-END DIAMETERS EQUAL TO AND GREATER THAN 14 CM

- Measure the shortest small-end diameter inside the bark through the centre of the log. Round down to the nearest even 2-cm interval.
  Example: 16.00 – 17.99 cm, record as 16 cm.
- Measure the longest* diameter inside bark through the centre of the log. This need not necessarily be at right angles to the shortest diameter. Round down to the nearest even 2-cm interval. Note that the commercial convention in NZ is to measure the second diameter at right angles to the shortest.
- If the shortest of these two diameters is between 14 and 38 cm (inclusive), then for every difference of 6 cm add 2 cm to the shortest diameter.
- If the shortest of the two diameters is equal to or greater than 40 cm then for every difference of 8 cm add 2 cm to the shortest diameter.
  Examples:

"Shortest"	"Long"	Difference	Record as
13	20	7	13
16	20	4	16
16	22	6	18
16	28	12	20
38	44	6	40
40	44	4	40
40	48	8	42

C.3.2 Length
Length is defined as the shortest distance between the sawn log ends. Lengths are measured in metres and tenths of metres and rounded down to each fixed-length class. For most export sales there is an agreed overcut (about 0.1 metres) to ensure that logs are not less than the fixed lengths negotiated with the buyers.

C.3.3 Volume

1. FOR LOGS LESS THAN 6 M LONG

V (m^3) = (D^2*L)/10 000

where D = shortest diameter
L = length

2. FOR LOGS EQUAL TO OR GREATER THAN 6 M LONG

V (m^3) = (D + [L'-4]/2)^2*(L/10 000)

where D = shortest diameter
L = length
L' = length in metres rounded down to nearest whole number
(L'-4)/2 = a factor for taper.

Example: Short diameter = 26 cm
Long diameter = 32 cm
Length = 8.1 m

Therefore D = 28, L = 8.1, L' = 8

V = (28 + [8 – 4]/2)^2*(8.1/10 000)
= ((30)^2*8.1)/10 000
= 0.729m^3 or 729 dm^3

Volumes are calculated to four decimal places and rounded to three.

CONSULTATION RECOGNITION

The following have applied for recognition as general forestry consultants in New Zealand and overseas.

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Owen Cox	Wellington
Neil George Woods	Auckland
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