Variability in JAS/tonne values

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Abstract

This paper shows how weight estimates, Japanese Agricultural Standard (JAS) volume, true volume-to-weight conversion and scaling affects JAS/tonne values. Three years of data collected from a port and weighbridge operations are used to show the magnitude of changes in JAS/tonne values. It is concluded that JAS and basic density have a significant effect on JAS/tonne. There is also a statistically significant change in truck tare weight by season and time of day. Therefore load weight based on estimated tare also affects the JAS/tonne ratio.

Introduction

For the log export market, it is customary for harvesting and cartage contractors to be paid on tonnes, but port services contractors are paid on JAS. Logs are sold in cubic metres (JAS). Trucking companies are generally paid in tonnes and have a vested interest in not under-weighing. The term JAS/tonne is used as an alternative for the domestic cubic metre per tonne conversion. A low JAS per tonne conversion will give a small volume and therefore small revenue for the relatively high weight on which costs are based.

Alternatively, a high JAS/tonne would artificially increase stevedoring load rates and vessel stow factors. An unanticipated low JAS/tonne conversion can result in an export operation making a financial loss. This is due to cartage and logging costs being based on $/tonne rates, which converted to JAS increases the $/JAS ratio. JAS/tonne conversion values may be reasonably predictable for large consignments of logs from one source. For smaller consignments suppliers are often surprised by unacceptably low JAS/tonne conversions, which are dependent on:

- Weighing method – the nett weight of loads is dependent on the accuracy of the weighbridge (if any) and the validity of tare weights for the given truck
- JAS volume – this is affected by log size, log taper and length
- True volume-to-weight conversion – this will change with stand age, season, amount of bark, length of storage and log size
- Scaling – volume bias in scaling directly affects the JAS-to-weight ratio.

Actual tare weight data and export data from deliveries to a New Zealand port are used to show actual variability in JAS/tonne values over a three-year period. This paper then covers the contribution of the various factors in JAS/tonne values.

Variation in JAS/tonne ratios from an export operation

Log grade and season

All of the docket information from deliveries to a New Zealand port over the last three years (2012 to 2015) were compiled. They required some screening because the truck weight information was either missing or deemed unreliable. Therefore JAS/tonne ratios were restricted to values between 0.6 and 1.499, which left 136,032 loads for the analysis. The data represented 26 forests, 12 suppliers, 36 log grades and 80 carriers. Therefore analysis was restricted to the principal grades, forest areas and carriers, represented over the whole three-year period. Log grades are identified by their generic names. Table 1 shows the difference from the average JAS/tonne by grade, and the maximum range in factors due to season.

Table 1: Average and range of JAS/tonne ratios by log grade

Log grade	Percentage change in average JAS/tonne conversion		
	Mean	Minimum	Maximum
PE	+10.6	+5.8	+17.0
A	+2.8	−1.3	+7.3
K	−0.7	−5.2	+5.6
KI	−2.8	−7.0	+3.8
KIS	−13.3	−22.4	−4.3

For example, the JAS/tonne for KIS grade logs is 13.3% lower than the all grade average. In summer this difference reduces to –4.3%, but in winter increases to –22.4%. It would be considered normal for log length to have an effect on JAS/tonne conversion within grades. In this analysis, 88% of the volume was from logs less than 6.0 m long and 27% of the volume was from logs of 3.8 m in length. It can be assumed that length has a minimal effect on the mean ratios in Table 1.

The seasonal trends for PE, A, K and KIS grades can be seen in Figure 1.

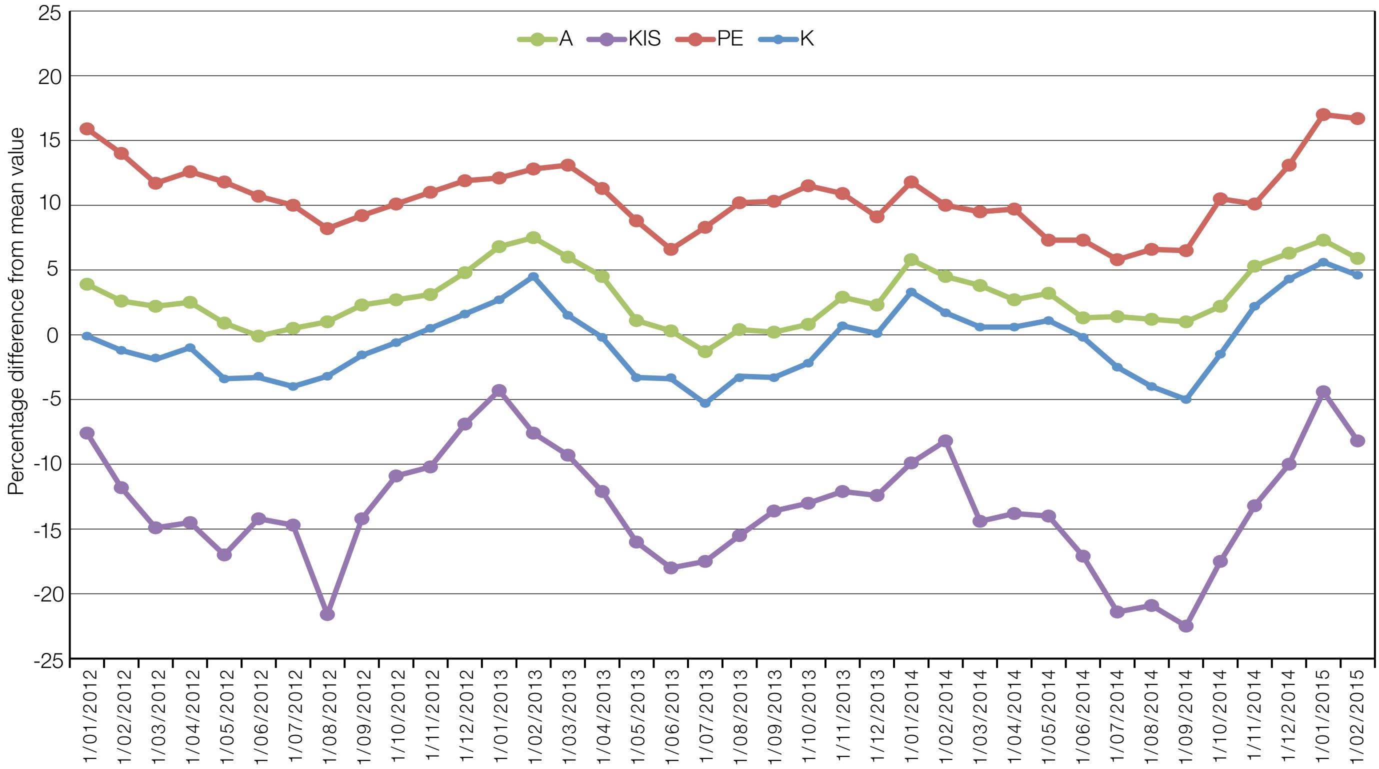

Figure 1: Percentage change in JAS/tonne by grade over time

In Figure 1, it can be seen the low conversions generally occur in the winter months and high conversions in the summer months.

Source

The truckloads of logs originated from 26 separate forest areas. Within each geographical region, JAS/tonne conversions may vary due to soil type, altitude, age profile or log grade mix. Table 2 below shows the difference from the average conversion for the five main forests represented over the three years.

Table 2: JAS/tonne conversions by forest area

Source	Difference from mean
1	−6.2%
2	+1.5%
3	+1.4%
4	+4.4%
5	−3.5%

There is a 10% range in conversion factors depending on the forest source, demonstrating that JAS/tonne values should not be assumed to be relevant over more than one forest. Logs are transported by a range of carriers. The data were analysed to examine whether there were any trends in JAS/tonne due to using one carrier over another.

Table 3 shows the percentage difference from the three-year average conversion for seven principal carriers carting from the same forest areas.

Table 3: Percentage difference in JAS/tonne by carriers from two separate forest areas

Carrier	Percentage difference from average JAS/tonne	
	Forest 1	Forest 2
1	+0.2	−2.9
2	+1.2	−1.8
3	+0.8	−3.6
4	+4.9	−4.8
5	+0.8	−2.1
6	−1.5	−3.7
7	+0.9	−3.0
Range	6.4	3.0

The range in average JAS/tonne is 6.4% from forest area 1 and 3% for forest area 2. The above carriers all carted over a three-year period and carted from the two forest areas over the same three-year period. It is assumed that all carriers carted equal amounts over the year, and that the distribution of grades is similar for each carrier from the same forest. The results show that it would be unwise to apply average JAS/tonne values for a given forest without some knowledge of the possible differences between carriers.

Derivation of weight

Weighbridges

Load weight of a truckload of logs is generally derived using a weighbridge or occasionally loader

scales. The legal tolerance for most weighbridges is ±40 kg for 10–40 tonnes capacity. Weighbridges require a minimum annual testing and certification. However in New Zealand there is no legal requirement to disclose the degree of adjustment a weighbridge requires to bring it to a certifiable standard.

Tare weights

The weight of logs (including bark, foreign material and any agreed overcut) is derived from the gross weight of the loaded truck minus the unloaded weight of the truck unit. The unloaded or tare weight of the truck may be achieved from re-weighing of the truck immediately after unloading, or from applying an estimated tare weight for truck and trailer units. The estimated tare weight may be achieved from an actual weighing on a given weighbridge, or given an arbitrary one based on the original registered value. Although a loaded truck may be weighed within some reasonable error limits, a nett weight may be subjected to larger additional various errors due to invalid tare weight.

In order to study the variation in truck tare weights, data for six trucks were examined over a three-year period (2012–2015) from a weighbridge where trucks are weighed-in loaded and weighed-out empty. In total, there were 3,038 tare weight observations spread over truck, truck and trailer, and trailer combinations. Care was taken to remove 'outliers' or apparent errors from the data so real trends in tare weights could be examined. A general linear model was used to study average effects combined over the six vehicles.

It was found tare weight changes over time of day and month are statistically significant. Figure 2 shows how the tare weight for an average truck varies during a 24 hour period. The bars on the graph show the standard errors at each point.

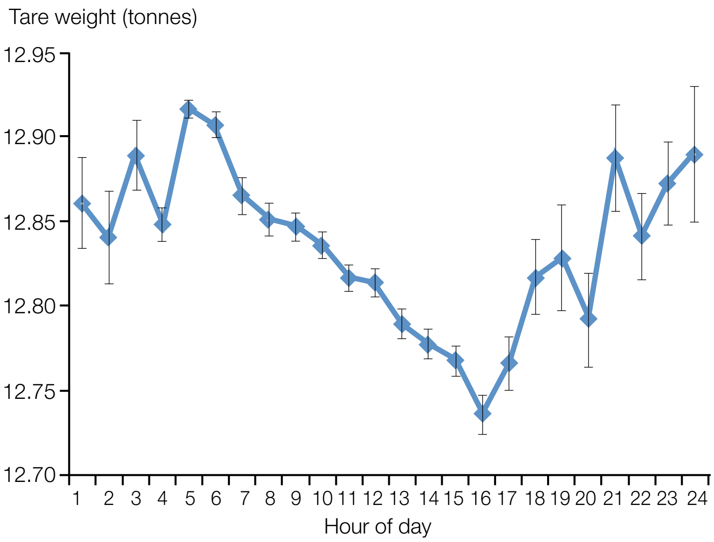

Figure 2: Average tare weights for trucks over a 24 hour period

It can be seen there is a consistent reduction from 4:30am to 3:30pm as the fuel load decreases. The tare weights for the remaining hours are more variable, presumably due to the various refuelling habits. Overall average tare weight has a range of about 200 kg (0.7% of load weight).

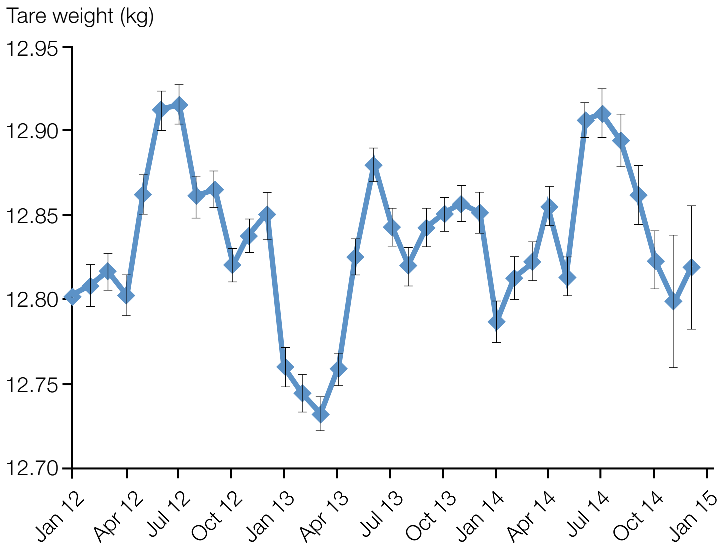

Figure 3: Truck average tare weight by month and year

The average tare weight of trucks was then examined over time of year. Figure 3 shows average truck average tare weight by month and year.

Average tare weights are highest in the winter months and lowest in the summer months. The tare weight maximum variation of up to 200 kg is presumably due to the presence of mud and foreign material over the winter wet periods.

The findings shown in Figures 2 and 3 are averages that would apply to a fleet of trucks, but for individual trucks, operators would experience much greater variations in truck tare weight. Tare weights for one truck and trailer unit A (595 observations) were examined to show variations within one day. Figure 4 shows the tare weight difference from the average tare weight during the day, and also the maximum difference in tare weights for each hour of the day.

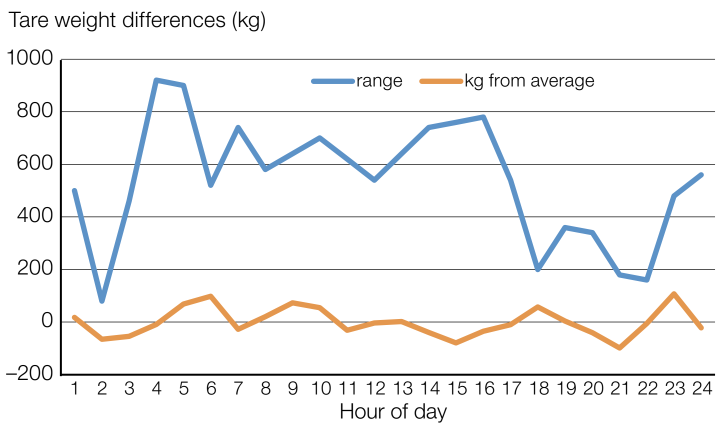

Figure 4: Changes in tare weight over 24 hour period for truck and trailer unit A

The daily tare weight average in Figure 4, and the average for each hour of the day (brown line), ranges from –98 kg to +108 kg. The blue line shows the difference between the maximum and minimum tare weights for each hour of the day. The smallest range in tare weights occurs at 1:00am and between 6:00pm and 10:00pm. The maximum difference for truck A is 920 kg, which is more than 3% of the load weight.

Tare weights for one truck unit B (1,186 observations) were examined to show variations over calendar months. Figure 5 shows the average tare weight difference by month compared with the 12 month average, and also the maximum difference in tare weights within each month.

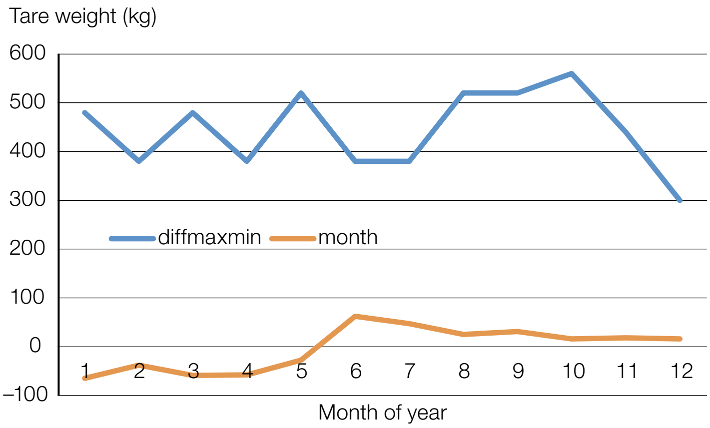

Figure 5: Changes in tare weight by month for truck B

Compared with the annual average for truck B, tare weights are lowest in January (–65kg) and highest in June (+62kg). From June, average tare weights gradually reduce. The maximum range in tare weights for any month (blue line) is between 300–560 kg. The tare weights of trailer units were examined separately and the average tare weight varied by approximately 230 kg.

JAS volume

Small-end diameter and length measurement

JAS volume is derived from small-end diameter, length and a formula taper, or no taper at all for logs that are less than 6.0 m long. To understand the effect of JAS volume on JAS tonne values, it is necessary to compare the JAS volume estimate with the 'true' cubic metres used for domestic logs and tree volumes. As JAS volumes are dependent on log taper, log diameter and length, the effect of each component will be shown separately.

Figure 6 shows the change in JAS to cubic metres for a range of small-end diameters and the current average log taper of 1.3 cm/m for export logs.

It can be seen in Figure 6 that an average small-end diameter of 22 cm gives a JAS/m³ value of 0.91, whereas an increase of 10 cm in diameter gives a JAS/m³ of 1.01. That is a 10% change in the JAS/m³. Note

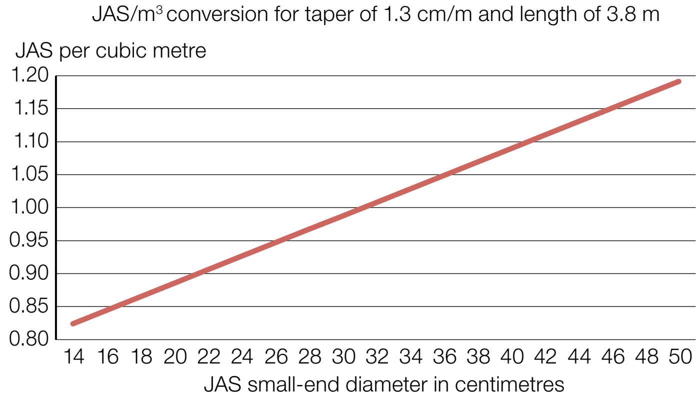

Figure 6: Change in JAS/m³ conversion on small-end diameter

that to achieve a given JAS small-end diameter, the true diameter needs to be approximately 2.0 cm greater.

As mentioned earlier, the JAS formula has no adjustment for taper on log lengths less than 6.0 m in length. This means as log length increases, the amount of ignored taper wood also increases. For longer logs (6.0 m and greater), the taper is approximated by adding 1.0 cm to the small-end diameter for each 2.0 m increase in length. Thus a 6.0 m log length has a 1.0 cm increase, and a 12 m log a 4.0 cm increase in small-end diameter.

Figure 7 shows the decrease in JAS/m³ on log length up to 6.0 m, and also the increase in JAS/m³ for lengths of 6.0 m and greater.

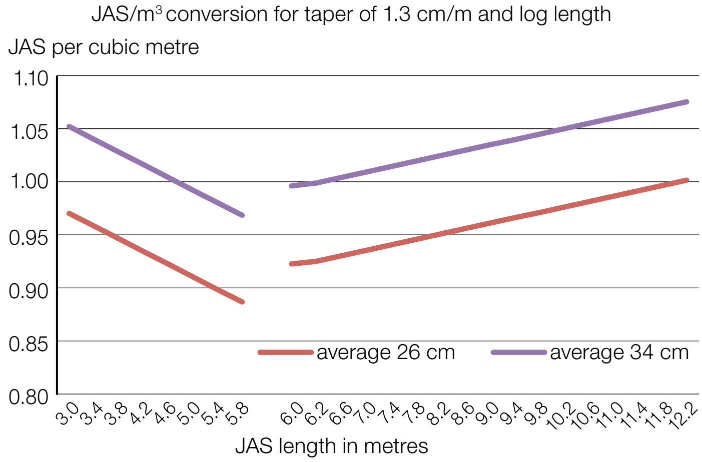

Figure 7: Change in JAS/m³ conversion on log length

For example, a 3.8 m log with a small-end diameter of 26 cm has a JAS/m³ conversion of 0.95 and a 5.8 m log has a conversion of 0.89 JAS/m³, which is approximately 7% less. For length increase from 6.0 to 12 m with taper and small-end diameter constant, the JAS/m³ increases by 7% and 8% for average diameters of 24 and 34 cm, respectively.

Log taper

Due to taper being ignored for log lengths of less than 6.0 m, actual taper has a large influence on the actual JAS/m³ conversion, as shown in Figure 8.

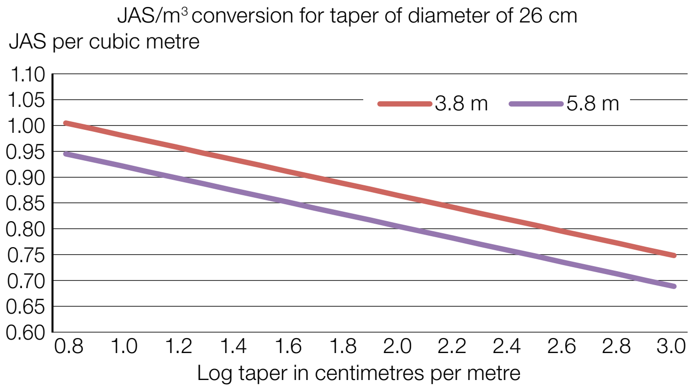

Figure 8: Change in JAS/m³ conversion on log taper

For example, a shift in log taper from 1.3 to 2.0 cm/m will reduce the JAS/tonne conversion by about 10%. In practice, estimates of real log taper are needed for the various age and log size assortments, to establish whether the JAS/m³ values are outside that expected from the national average taper of 1.3 cm/m.

True volume-to-weight conversion

Part of the variability in JAS/tonne is due to the volume-to-weight relationship of the logs. The relationship should be considered separately so that it is not confused by the effect of varying JAS volume estimates due to log dimensions.

Bark

The weight of a log or truckload of logs is the weight of the bark attached to the log and the wood. Apart from the moisture content of the bark, any foreign matter attached to the bark in the form of mud, sand, road metal or ice and snow will also add to the weight. In recent years, the use of processors and de-limbers has reduced the amount of bark retained on the logs, and this has reduced log weight through the absence of heavy bark.

Basic density and moisture

The weight of actual wood depends on its basic density and the moisture content of the wood. The 'outer wood' or sapwood represents the last 10 years of growth (in radiata pine) and has a high moisture content. Therefore the amount of sapwood has a large effect on the green density. Young trees and logs cut from the upper part of the tree stem may have a large percentage of sapwood. The moisture content of radiata pine wood in the tree does not vary between summer and winter.

Therefore weight-to-volume conversion factors are dependent on age and a mixture of other factors that are summarised as follows:

- Stand age – as a rough rule the conversion factor changes 1% for every 2.5 years change in stand age. Tree age accounts for 40% of the variation in conversion factors (Ellis, 1984)
- Season – factors also decrease in winter due to bark retention and the amount of water and foreign material contained in the bark. The seasonal effect can also be increased with the use of processors, which remove bark and allow more rapid drying of the outer sapwood in summer
- Time since felling – felled trees with branches attached will lose moisture from that part of the tree. Moisture loss is more rapid in summer than in winter, especially in windy areas
- Log size – the log size or position of log in a tree also has a bearing on the conversion factor which can range from 0.8 m³/tonne to more than 1.0 m³/tonne
- Region – where the basic density of wood is low the moisture content of wood is increased, reducing the volume-to-weight conversion. Altitude and rainfall may also affect bark thickness and moisture retention
- Branching – trees with large branches have low conversion factors because calculated volume does not include nodal swelling, but this heavy nodal wood is included in the weight
- Overcut – where logs are sold on a fixed length it is customary to include at least 10 cm of 'overcut'. Excessive overcut will increase log weight for a fixed volume.

Within each species there will be substantial variation as demonstrated in Table 4, which shows likely ranges of the average weight-volume conversion factors for mature radiata pine logs.

To derive JAS/tonne the JAS/m³ figure is multiplied by the figure in Table 4. For example, an estimated 0.865 JAS/m³ (3.8 m length, 18 cm sed, 1.3 cm/m taper) multiplied by 0.9 m³/tonne (column 3, 12 years age) gives 0.778 JAS/tonne.

Table 4: Changes in radiata pine conversion factors. Source: Ellis and Elliott, 2001

Variable	Low	Value (m³/t)	Average	Value (m³/t)	High	Value (m³/t)
Age	12 years	0.90	28 years	0.96	53 years	1.06
Season	winter	0.94		0.96	summer	0.98
Storage			fresh	0.96	20 days	1.02
Bark			on	0.96	off	1.00
Size	10 cm s.e.d.	0.80	25 cm s.e.d.	0.96	50 cm s.e.d.	0.96

The stated figures are based on observed means from independent data sets, but do not take account of interactions between variables, and therefore should not be used as a substitute for collecting sample data. It should be noted that apparent regional differences in conversion factor may largely be age differences in your own sample data.

Log scaling

In New Zealand, the volume of logs for export is derived from JAS, which is described in Ellis and Crawley (2014). The JAS volume is derived from the manual measurement of the small-end diameter of each individually tagged log. The under-bark small-end diameter used in volume calculation is based on the shortest diameter through the geometric centre and a second diameter at right angles to the first. Length used in the volume calculation is nominal in that the actual log length includes 10 to 15 cm overcut.

JAS scaling is generally carried out while the logs are held in a truck or wagon bunk. Because it is not possible to see along the whole length of the logs, there are some additional details in the application of the JAS scaling rules. Those scaling details are agreed by consensus between marshalling companies and the exporters. As most export logs are re-scaled at their destination, there is a requirement that the original scale is done to a given accuracy. This varies between customers, but the common criteria is that original scaled volume is within 3% of the volume of an independently audited sample of logs.

Summary of variation sources

JAS/tonne can change due to weighing, JAS volume variation, time of year, basic density of the logs, scaling and log grade. The magnitude of changes are seen in Table 5.

As most JAS/tonne values are below 1.0, a 10% reduction would result in reduction of at least 0.09 JAS/tonne.

Discussion

In this paper, the principal factors such as season, wood density, log grade and JAS volume estimates have a large impact on JAS/tonne values. Change in JAS/tonne due to scaling is similar to the change due to the use of incorrect truck tare weights. This is demonstrated by the range in JAS/tonne values (6.4% and 3%) from the same forest source.

Most of the log transactions and contracts are based on tonnes. Although weighbridges are required to be certified, the application of correct tare weights is left to the transport company. Where no weighbridge is available, truck nett weights can be estimates. Therefore it is vital a valid weighing system is established before deliveries commence.

Analysis of tare weights has excluded obvious recording errors and outliers which would be present in practice. It is also apparent that trucks and trailers are interchanged, and as a result the incorrect tare may be applied. Examination of truck tare weights shows there is a statistically significant daily and seasonal trend in the magnitude of tare weights. It is normal for the averages to differ by 200 kg and individual truck and trailer units to vary by 800 kg or more in one day. Study data came from the central North Island. In clay country, one would expect higher mud retention on truck and trailer units and therefore greater seasonal differences in tare weight.

Setting an average tare weight too low will artificially increase the load weight and therefore overcharge cartage and decrease the JAS/tonne value. One commonly ignored component is the addition of a 100 kg driver that is added to the load weight, but been ignored in the tare. Another component is that a new truck tyre is about 20 kg heavier than a worn one. The increase in tare weight through new tyres would be significant if applied over multiple wheels. It is estimated for each unaccounted 100 kg per trip, 66 tonnes would be accumulated over a working year at three loads per day.

Table 5: Magnitude of changes in JAS/tonne conversion

Source	Variation in JAS/tonne	Assumption
Tare weight	0.4%	For every 100 kg change in 28 tonne load
Season	8–16% range	From low in winter
Wood density	11% range	Radiata pine in one region
Scaling	± 3%	Common industry range
Log grade	KIS −13.3% PE +10%	Difference from mean conversion
JAS scale estimates		
Taper	−10%	Every 0.7 cm/m increase from 1.3 cm/m average
Length	−7%	3.0 to 5.8 m increase
	+7%	6.0 to 12 m increase
Small-end diameter	+10%	Increase from 30 to 40 cm
	−10%	Decrease from 26 to 18 cm

With weighbridges, 'weigh-in/weigh-out' systems should be used. Where this is not practical, setting of stored tares should be carefully monitored and updated regularly throughout the year.

Conversion to cubic metres is required for stand reconciliation and export sales. The larger suppliers of logs have accumulated statistically valid sample data to give realistic average conversions from tonnes to cubic metres. The small supplier does not always have accurate information and an invalid JAS/tonne conversion can result in a financial loss. Sample data is a necessity in establishing JAS/tonne averages for new harvesting areas.

Conclusions

Analysis of actual data shows that there is large variation in the JAS/tonne ratio. This is shown to be due to variation in JAS volume on grade, length, log size and taper, and log weight affected by season, bark content and basic density. Because the nett weight of loads is commonly derived from estimated tare weight, this can also have a significant effect on the accuracy of load weight and the JAS/tonne value, and therefore returns to forest owners and exporters.

Acknowledgements

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