THE CASE FOR CUBIC LOG SCALE

1. INTRODUCTION

The history of scaling rules or log scales in the US goes back to the earliest lumbermen of North America. Many proprietary systems were used in the 18th and 19th centuries. Historically there has been over 95 different log scales used in North America; with the majority of these finding use in the US. Currently, nine methods of measuring roundwood dominate in the US: "short log Scribner" in California, the interior west, and the northern Great Lakes region; "long log Scribner" west of the Cascade mountain crest in Oregon and Washington, and coastal Alaska; Doyle in the south-central, southeast, the Midwest and southern Great Lakes region; International ¼" , in the northeast and pockets of the Midwest and south; the Maine and Bangor rules in the state of Maine; cord scale and weight used throughout the US for lower valued wood such as pulpwood, firewood, but also moderately valued sawlogs; and finally cubic, used in the southeast and by a few companies and agencies in the west.

Excepting weight, cubic and cord scale, these rules tried to approximate the recovery in board feet of lumber from a log of a given diameter and length. Again, except for cubic, weight and cord scale; none of these methods correlate with one another across a spectrum of diameter and length combinations, thus making conversion factors difficult to obtain. In addition, there are many local variations within each of these rules in regards to diameter measurements, length segmenting, defect deductions and whether or not taper is accounted for and to what extent (see section 2.1.2). Furthermore, these rules do poorly at predicting product recovery unless diameter and length combinations can be accounted for, with a nod to the International ¼" in that it does a fairly accurate job of predicting lumber recovery (particularly for hardwood lumber in "typical" diameter ranges, e.g. 10" – 20" small end diameter logs).

For the purpose of this document, cubic will be primarily compared with the Scribner variations of the western US, as these rules are fairly standardized via the USFS scaling handbook and the Northwest Log Rules Advisory Group regulations.

2. CUBIC COMPARED TO BOARD FOOT MEASURE

2.1 Consistency and precision

2.1.1 What makes cubic more consistent and precise

Aside from a consistent standard, cubic is more accurate than the BF measures simply because it makes no assumptions as to manufacturing efficiency, products made, it accounts for taper, measures relative volume between small diameter and large diameter logs, and it is rounded in small units (to one-tenth of a cubic foot). It also addresses defects in a manner that more accurately accounts for the volume available to manufacture a product as opposed to the BF measures which often over-deduct (typical defect percentage for cubic is about 2/3rds that of the BF rules). The conventions for rounding diameters and nominal length measurements (trim allowance) is the same for USFS cubic as it is for USFS Scribner short log. While these procedures do bias cubic toward a 3-7% understatement of volume as determined by conventional diameter rounding logic, and not measuring using the length with trim to calculate volume, this bias is rather small and relatively consistent. In addition, the Smalian formula (used of USFS cubic) is predisposed toward overstating log volume by roughly 3%, thus the true impact of diameter rounding logic and nominal log lengths (trim allowance) is reduced by roughly 3%. While it is true that there are several variations of cubic measure used in the US (the USFS cubic handbook was not published until 1991), most all fit within the scope of the 3 to 7% variance mentioned above, because the overriding purpose of cubic is to at least in principal, measure displaced volume.

2.1.2 What makes board foot measure more inconsistent and arbitrary

Outside of the Scribner regions of the west and the state of Maine (International ¼", Maine and Bangor rules), there are no official scaling manuals to standardize procedures. Outside of these areas, diameters may be taken outside of both bark thickness, inside of one bark thickness, inside of bark; and the diameter taken may be truncated - 11.99 = 11", or rounded - 11.51" = 12". The two scale sticks in figure 1 are labeled as both being Scribner decimal C, but nothing indicates truncated vs. rounded diameter calibration (the catalog in which they were ordered did not indicate either) despite the fact that one is calibrated for truncated diameters and the other for rounded diameters (this will yield a 5 – 20% difference in volume depending on diameter). One will find the same situation with Doyle and International ¼" measuring sticks (some are rounded, some truncated). In addition, there are no voluntary or mandatory (or for that matter documented) guidelines to give consistency in procedures for defect deductions, or scaling long logs (generally over 20'). These variables can lead to significant variation in volume assigned (again from roughly 20% in smaller diameters to just under 5% in large logs) and are seldom clearly understood and quantifiable to all parties of a log transaction. To be fair, it should be said that this particular component of inconsistency found in BF measures is related to the lack of standards and not necessarily to the unit of measure itself and even cubic can be inconsistent if measurement conventions are not standardized. There are, however, many other inconsistencies with BF measure, which will be discussed.

Figure 1: Two Scribner scale sticks used in the central and eastern US; one with truncated diameters the other with rounded diameters

To illustrate some of the erratic nature of the BF measure, let's examine five average sized tree stems (randomly selected from a stem profile study in the Northern Rockies region (figure 2). These stems were measured every 8' from breast height to the merchantable top (minimum 4.5") in the nominal 2' multiple sawlog lengths. The minimum scenarios are obtained by bucking the stem at points which yield the least volume and the maximum scenarios are obtained by bucking the stem to maximize volume. In all cases, 100% of the stem was utilized to the nominal merchantable height, the USFS scaling standards were adhered to, and the stem was manufactured into lengths that are acceptable to most sawmills (no logs shorter than 8' nor longer than 40' in nominal length were assumed). As can be seen clearly in figure 2, there can be substantial differences in volume if one purposely varies manufactured lengths to take advantage of volume rounding points, scaling cylinder length (e.g., 20' for short log Scribner, 40' for long log Scribner), and rounding points for diameters. Note that even when attempting to bias the cubic volume by taking advantage of diameter rounding points, the volume changes very little in relative terms (3.4%). While it would be difficult to manipulate volumes to this extent in the field; it is not too difficult to bias volumes by a significant portion of that shown in Figure 2 simply by utilizing maximum segment lengths (or minimizing segment length) or points where volumes change due to volume rounding conventions (to the nearest 10 BF for Scribner or 5 BF for International ¼"). Try to imagine any other sector of American business where the raw material used has a unit of measure which can vary to such a degree for the same usable volume (in this example, 40% for Scribner long log, 25% Scribner short log, and 9.5% for International ¼"). For those of you who are unfamiliar with the mechanics of the BF rules vs. cubic, you may want to examine: Spelter, 2004, *Converting among Log Scaling Methods* (http://www.fpl.fs.fed.us/documnts/pdf2004/fpl_2004_spelter001.pdf) for more in-depth explanation.

Figure 2: Five trees merchandized to minimize volume vs. merchandized to maximize volume.

			Scribner SL		Scribner LL		International 1/4"		USFS Nat. Cubic	
Species	DBH – IB *(in)*	Merch Ht *(ft)*	BF Min	BF Max	BF Min	BF Max	BF Min	BF Max	CF Min	CF Max
Grand Fir	9.3	48	70	100	70	90	90	100	16.6	17.3
Douglas Fir	16.6	78	330	370	230	340	400	425	64.4	67.1
Ponderosa Pine	14.5	64	200	270	180	240	255	300	43.9	45.3
Engelmann Spruce	9.0	48	60	80	50	70	85	85	15.5	15.6
Lodgepole Pine	10.1	40	50	70	40	60	65	70	13.4	13.8
Total volume			710	890	570	800	895.0	980.0	154.2	158.7
% dif. (min to max)				25.4%		40.4%		9.5%		3.4%

2.2 Correlation with weight and other units of measure

2.2.1 Weight

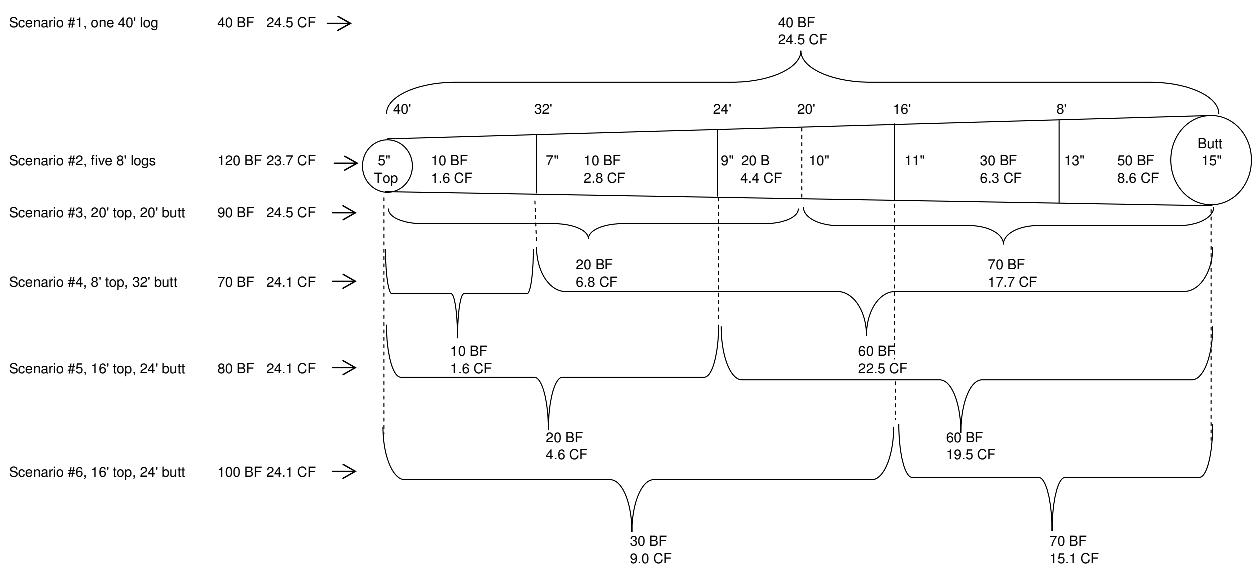
As weight is a key driver of costs in terms of harvest and transport of logs, and because it is easily available via drive on weight scales; it is often used to quantify and extrapolate log volume. Logs are also often bought and sold via weight measure. As trees cannot be weighed on the stump and recovery ratios are usually calculated via volume in vs. volume out; it is important to be able to correlate this relationship. In general, when examining truck loads of logs off of a given timber sale (with similar characteristics and log manufacturing criteria), one might find a coefficient of variation (CV) of about 5% based on the pounds per cubic foot, while the CV for Scribner short log (lbs per BF) will be roughly 50% higher, e.g., 7.5%.

When looking at the variation by log diameter one will find this trend magnified exponentially. For example, based on a weight analysis of Western larch logs with a given small end diameter: 6" logs averaged 65.7 lbs per CF (net volume), 10" averaged 65.4 lbs, 14" logs averaged 66.9 lbs (roughly a 2% change from high to low); the same logs had a lbs per BF relationship of: 6" logs averaged 15.2 lb per BF (net volume), 10" averaged 11.7 lbs, and 14" logs averaged 10.7 lbs (roughly a 30% change from high to low). If one is to isolate length within a given diameter, this variability will increase again exponentially, e.g., again using western larch and a small end diameter of 6”: a 16’ long log will have roughly a 12.6 lb per BF ratio, while a 14’ log with the same small end diameter would have roughly a 21.5 lb per BF weight factor using the standard Scribner log rule; the cubic weight to volume relationship will change little if any.

2.2.2 Automated measuring devices

Most modern mills are now utilizing log scanners for primary breakdown optimization equipment. These scanners have the ability to accurately calculate volume, which can be used for usage and recovery calculations; however, this benefit does not work very well when the unit of measure is BF. Logs are often delivered in lengths that differ from the lengths utilized in the mill, e.g. a 40’ log is often cut into two 20’ logs in a dimension mill, four 8’ logs in a studmill, etc. Figure 3 shows a log stem segmented into short logs five different ways. Assuming the log was delivered as a 40’ and was scaled in Scribner long log (used in Oregon, Washington and Alaska), the log would have 40 BF, but it could have as much as 120 BF if bucked into five 8’ logs (as would be the case in a mill utilizing 8’ milling lengths. It is interesting to note that this log stem could have 40 BF, 70 BF, 80 BF, 90 BF, 100 BF, or 120 BF depending on how it was presented to the automated measuring device (or a log scaler). In contrast, cubic ranged from a low of 23.7 CF to a high of 24.5CF (only a 3.3% difference as opposed to the 200% difference for Scribner!). Obviously, when scanning a log after merchandizing at the chop-saws, it will not match the original BF Scribner volume. In addition, this log clearly illustrates the concept shown in figure 2.

Figure 3: Scribner long log volume for a log merchandised five different ways.



2.2.3 Stacked measure

In all regions of the US, stacked measure is utilized, both for measuring low valued logs (generally pulpwood) and for measuring logs inventoried in a log deck. The normal procedure is to measure the cubic space occupied by load or deck and utilize a factor to determine the log volume in that space. Cubic volume correlates well with stacked measure; normally there is between 60% – 70% solid wood contained in stacked logs with the remaining being bark and void. As the percentage of solid wood contained in stacked measure is more closely related to the straightness of the logs, lack of butt-flare, lack of knots, quality of stacking, and bark thickness; and not to log diameter; it should be no surprise that stacked measure does not correlate well with the BF measures in relation to cubic. This point is especially relevant to those who use stacked measure to assess log volume inventoried in log decks. For instance, a deck of logs which is 100’ long, 10’ tall and has an average width of 25’ (based on average log length) occupies 25,000 cubic feet and will more than likely have a volume of 15,000 to 17,500 cubic feet of solid wood, however, if the unit of measure is BF Scribner short log, the gross volume could be as low as 50,000 BF or as high as 130,000 BF depending on log diameter, length and taper. The same dynamics that affect log deck inventory come into play with cord measure, which is used for pulp (occasionally sawlogs in the Great Lake regions) A cord occupies 128 cubic feet of which 60-70% will commonly be solid wood. The BF contained in this cord can range from 240-630 depending on same variables that control log deck volume.

2.3 Product output (recovery)

For most forest products companies, the ability to predict product recovery from log volume is the most important single metric in determining what the value of a log is. There is no question that cubic can more precisely predict product recovery. Figure 4 shows five logs, in terms of length, diameter, log scale in Scribner BF, CF and weight, and lumber produced. The relative lumber volume produced is, in fact, representative of what one would typically cut out of logs with these attributes. As you can see, BF recovery ranged from 0.91 for the log #1 (9% under-run) to 2.73 for log #4 (173% overrun), which is a 200% change from log #1. The cubic recovery ranged from 6.7 BF lumber per cubic foot log (LRF) for log #1, up to an LRF of 7.9 for log #5, which is a much more reasonable 18% change (as a result of decreasing slab and edging losses in larger diameters).

Figure 4: Example of Scribner recovery vs. cubic recovery for five logs, each with 20 BF Scribner volume

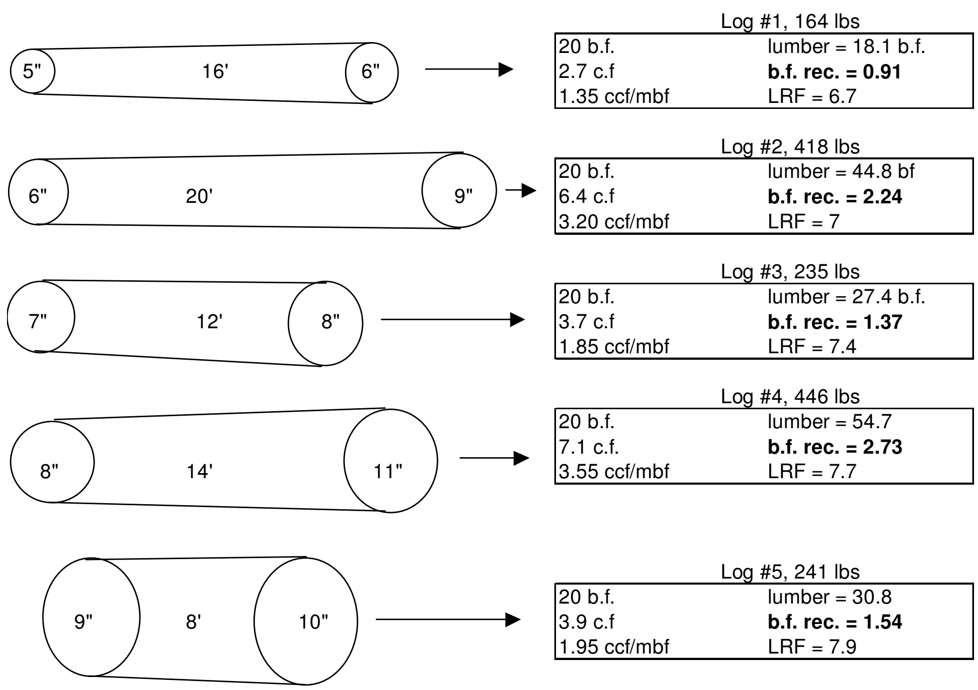
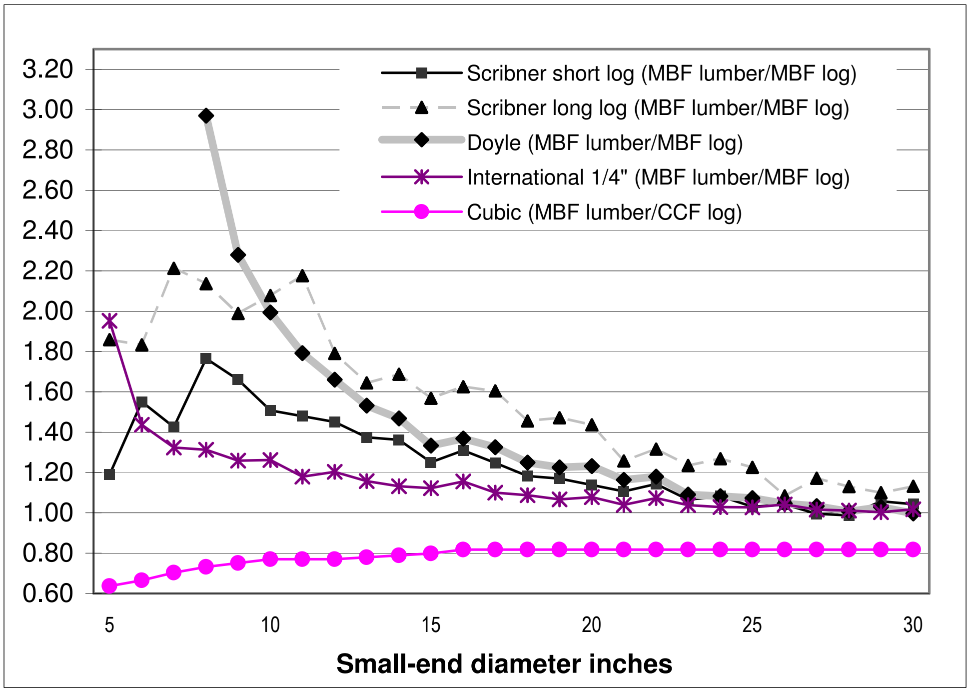


Figure 5 shows an example of lumber recovery by diameter for logs from 5" to 30" on the small-end with recovery based on BF lumber per BF log scale for the BF rules and MBF lumber per CCF (100 CF) for cubic log scale. Mills can have better or worse recovery than those shown dependent on the lumber product being produced and milling efficiency as well as, for the BF rules, the variables listed in section 2.1.2, e.g., variations in diameter measurement conventions (rounded vs. truncated) and the erratic nature of the BF rules as shown in figures 2 - 4. What is important to note from the graph is the relative change in recovery by diameter for the BF rules vs. cubic as well as the erratic trends for the two Scribner based rules. It is also easy to observe the convergence of log rules which occurs in the bigger diameters (20"+), which shows that the assumptions made when most BF log rules were created, matched the resource in use (big logs), but no longer are meaningful with the smaller logs that are the "bread and butter" of most forest products companies.

Figure 5: Example of lumber recovery for BF log rules and CF log scale



Note: MBF = 1,000 board feet; CCF = 100 cubic feet

Relative product recover trends for plywood and veneer are very similar to figure 4 except the product output measure will be square feet 3/8" instead of MBF, and cubic has an even more linear relationship to diameter vs. BF rules, i.e., the performance of cubic is even better than it is for lumber relative to BF log scale.

Forest product companies that use logs to manufacture chips will find that cubic measures product output extremely accurately while the BF rules do a poorly. The relationship of cubic volume to bone-dry weight, which is the primary way of measuring the product (chips), is directly linked to wood cubic volume and specific gravity (density) and has little relationship to board footage, e.g., for Douglas Fir it may take 85 cubic feet to make a bone-dry unit (71 cubic feet per bone-dry ton), however the log volume needed as measured in BF can range from 260 – 600 depending on diameter and length.

3. SCALING COSTS AND PRODUCTIVITY

3.1 The scaling process

Of the companies that have made the switch to cubic scaling, the vast majority have done so without having to increase the workforce or incurring any additional scaling costs aside from the one-time cost of switching software and training scalers. The majority of scaling is now done via hand-held data recorders, which calculate volume for the scaler based on the key data points entered (species, length, small-end diameter, large-end diameter, and defect deductions. In addition, as cubic uses most of the key inputs that are needed for most BF log rules, many companies using cubic, duel scale, i.e., they scale logs once and obtain volumes in cubic and BF (usually Scribner long-log, Scribner short-log, or Doyle). The only significant additional work required with cubic is to measure large end diameters, which is necessary for Scribner short log in the west for logs over 20' in nominal length, but this data point, while not required for many of the BF rules utilized in the eastern half of the

US or in the coastal regions of Oregon, Washington and Alaska; significantly improves the accuracy of the data (thus adds significant value), and only increases scaling time slightly.

3.2 Sample scaling

Many larger consumers and sellers utilize sample scale of logs – generally quantified based on weight. Given the tight relationship cubic has with weight relative to the BF rules, and the fact that cubic volume is a better predictor of recovery, and thus value, than the BF rules (giving lower CVs as noted in 2.2.1); one can sample a significantly smaller percentage of cubically scaled loads, given the same confidence level (*t value*) and allowable sampling error, than one has to scale if using BF. For those utilizing sample scaling, scaling costs will actually be decreased over the BF methods.

4. CONCLUSION

While the primary intent of this paper is to point out the superiority of cubic for measuring volume and thus value of logs - there is also the issue of standardized scaling procedures (or the lack thereof) which further "muddies the waters". Those of us in the business of measuring logs for the purpose of buying and selling logs cannot satisfactorily wade through the erratic nuances of the BF log rules, let alone the undocumented and variable standards that are applied in some regions of the US. Now imagine small forestland owners who are tasked with trying to obtain the best price for their logs, and to find a logging contractor who can manufacture logs to a specification which maximizes value. Of course the log purchaser (generally the forest product company) has the same problem, albeit with a bit more experience at it than the small landowner.

There are issues with cubic that need to be resolved, such as butt-cut diameter measurements and cull determination, but these should be relatively simple to resolve (the current rules listed in the cubic handbook are cumbersome and not considered practical by many scalers). As to who, if anyone, would take the lead in moving industry ahead with cubic – there is no clear direction. The USFS spent decades on cubic implementation via the cubic log rules committee, but they no longer seem to have any desire to follow-through, and are no longer in as good of a position to wield influence as they once were. The forest products industry has a good track record of standardizing key measures: product grades and measurement via grading agencies, scaling standards on the west coast via the Northwest Log Advisory Group, and the AF&PA has been very successful at taking a leadership role in setting standards on environmental and sustainable timber harvest via the Sustainable Forestry Initiative (SFI). This type of voluntary direction would seem preferable to any kind of mandate from a government agency.

In summary, those of us in the log measurement arena, need to keep in mind that if our services, in this case scaling, no longer provides a unit of measure which gives buyer and seller a predictable measure of relative value, they will move to a different, more reliable unit, for instance, weight. This has already happened in many areas, and it would be a shame if scaling was dropped in favor of weight simply because we don't want to budge from "the way we've always done it" to a better way of measuring log volume.