Log Rules and Scaling

- Introduction to Log Rules
- Schribner, Doyle, and International
- Overrun and Underrun
- Board Foot Scaling
- Defects and Culls
- Measurements

Readings: pp 6-16 and pp 20-113 (lots of detail)

Log Rules: Introduction

A log rule is a table or formula that converts log diameters and lengths into estimated volumes.

Log scaling is the process of applying these rules.

Different rules exist including:
- Mill Tally Rules (used in custom sawing runs)
- Diagram Log Rules
- Mathematical Log Rules (formula built based on assumptions of kerf, taper, and milling procedures and not via regression analysis)

Although hundreds of board feet log rules have developed, it is very rare for the estimate board feet to ever equal the board feet of useable timber.

- Log rules are an approximation
- They provide buyers and sellers a consistent mechanism to trade timber
- In an ideal rule, log volumes should be correlated with log sizes over the entire range of sizes

However, few rules meet this standard.
Log Rules: Introduction

Differences between estimated and actual timber volume are due to the log rule assumptions:
• Logs are cylinders
• Taper is ignored or approximated at a fixed rate per foot
• Assumes all sawmills will operate at a standard level of efficiency
• A standardized sawing pattern is assumed
  - Logs will be sawed into boards of set thickness
  - Logs will be sawed with saws of a special thickness, i.e. the kerf

Minimum board length is the narrowest board for which volume can be estimated (usually 4-8")
Maximum scaling length is the longest log that can be scaled (critical if no taper is assumed). Usually, 16' in the east and 20-40' in the west
Log lengths are measured to nearest foot and diameters are measured inside bark (DIB) at the small end of the scaling cylinder. DIB is always rounded down.
The three most common log rules used in the United States are:
1. Scribner [decimal C] log rule developed in 1846
2. Doyle log rule developed in 1825

Log Rules: Developing a Rule – The Ring Method

In the ring method the slab is deducted before the sawdust. In the plank method the kerf sawdust is deducted before the slab.

Step 1. Calculate volume of cylinder

Step 2. Deduct for slab and edgings (USFS uses 2")
Log Rules: Developing a Rule – The Ring Method

Step 3. Deduct the kerf allowance

$T = \text{board thickness, } K = \text{kerf thickness}$

Example: 1” board with 0.2” kerf

$A(\%) = \frac{0.2}{0.2 + 1.0} = 14\%$

Example: 20’ by 16” log with above A%

Log Rules: Scribner Log Rule

This diagram rule was developed by J.M. Scribner. Assumptions:
- ¼ in kerf
- Minimum board length around 4’
- Perfect cylinders with no taper from small end of log

The perfect cylinder approximation leads to an underestimation in mill output that increases with the length of the log.

Grosenbaugh (1952) Approximation of Scribner Volume for 16’ logs = $0.8 \times (D-1)^2 - D/2$

Log Rules: Scribner Decimal C Log Rule

This is a modification to the original Scribner rule where all Scribner volumes are rounded off to the nearest 10 bd ft.

In this example, a 16 foot log with a DIB of 20 = 280 bd ft
Log Rules: Doyle Log Rule

This rule was developed by Edward Doyle in 1825 with overrun built into the equation:

\[ \text{board feet} = \left( \frac{D-4}{4} \right)^2 \times L \]

For 16' logs this reduces to \((D-4)^2\)

Although based on flawed algebra this rule is widely used in the eastern and southern United States.

This rule is very inaccurate

In this example, a 16 foot log with a DIB of 20 = 256 bdft

The Doyle log rule underestimates in small logs and overestimates in large logs.

Log Rules: International ¼ Log Rule

The international rule was developed by Judson Clark in 1906. It is one of the few rules that account for log taper and is fairly accurate.

Taper is assumed at ½ inch per 4 ft.
Kerf allowance is ¼ inch + 1/16 inch for shrinkage = total of 5/16 kerf deduction

\[ \text{board feet} = 0.905 \times (0.22 \times D^2 - 0.71 \times D) \]

Although the international ¼ rule is the most consistent and is a standard in many states most foresters find themselves using the rule on inventory data and using Scribner or Doyle on logs.
Log Rules: International ¼ Log Rule

The international rule is considered the most consistent log rule.

In this example, a 16 foot log with a DIB of 20 = 290 bdft

<table>
<thead>
<tr>
<th>DIB (inches)</th>
<th>Length (ft)</th>
<th>Volume, bdft</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>14</td>
<td>5</td>
<td>28</td>
</tr>
<tr>
<td>16</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>18</td>
<td>7</td>
<td>36</td>
</tr>
</tbody>
</table>

In Summary:

International ¼ considered most accurate

Scribner is always more conservative than the international rule

Doyle is to be avoided due to large errors.

Log Rules: Comparison

- In Summary:
  - International ¼ considered most accurate
  - Scribner is always more conservative than the international rule
  - Doyle is to be avoided due to large errors.

Log Rules: Overrun and Underrun

Overrun occurs when the lumber output at the mill is greater than expected by the log rule.

Underrun occurs when the mill output is lower than expected.

\[
\text{Over/Underrun} = \left( \frac{\text{lumber tally} - \text{log scale}}{\text{log scale}} \right) \times 100
\]
Log Rules: Overrun and Underrun

Comparison of overrun in the Doyle and International ¼ rule for real mill data.

The overall error in the International ¼ rule was 3.3%, while the Doyle was 36.9%.

Log Scaling: Introduction

When deducting defect from logs there are two classes: Grading defects and Scaling defects. Grading defects only impact quality and do not result in loss of wood volume. Scaling defects will result in volume being subtracted from the gross scale.

The location of the defect will affect the grading/scaling:
- Defects in the slab section don’t impact log products
- Defects in the center section will not be “grading defects”
- Defects in the quality section might also impact the volume.

Log Scaling: Introduction

As covered in an earlier lecture, defects are imperfections that will result in losses of wood volume during sawing:
- Interior Defects (Rot, insects, etc)
- Crooks, forks, and sweeps
- Wormholes
- Mechanical damage during felling and transportation
- Ring or cup shakes: the wood separates along the boundary between early and late growth
- Splits: lengthwise separations of the wood, due to the tearing apart of wood cells
- Checks: splits that occur across growth rings
Log Scaling: Introduction

Imperfections that affect the quality of the wood are not considered as defects when scaling:

- Sound knots: these occur solid across the face and exhibit no signs of decay
- Coarse grain
- Small pitch pockets
- Sap stain

Defects that only penetrate 1” or less into the log can often be ignored as this wood is usually lost when the saws create the slabs.

Log Scaling: Introduction

There are 4 main types of defect-deduction methods:

1. Diameter-deduction methods
2. Squared-defect methods
3. Pie-cut methods
4. Length-deduction method

Diameter-deduction and squared-defect are not used in the field (usually reserved for scaling downed logs)

Pie-cut methods are used for surface defects (frost cracks and lightning scars) and length-deduction is used for internal fungus or structural defect

Log Scaling: Introduction

Logs are scaled as long as they fall within the scaling cylinder. Defects are only considered if they are within the scaling cylinder.

Diameter-reduction: Used for exterior defects (sap rot, checks, etc) – i.e. use a smaller cylinder

Squared-defect methods: Used on singular defects that are easily measured by the scaler

Pie-cut methods: Used when the defect is confined into pie-shaped sections of the log

Length-reduction: Used for butt-rots and crook defects – i.e use a shorter cylinder
Log Scaling: Introduction

Scaling straight and sound logs is achieved by measuring its length and diameter inside bark (DIB).

In this case the gross scale = net scale

Notes:
- Logs <6" are culled and not included in the scaling.
- When logs are halfway between graduations (e.g., 11.5), it’s usually to round down to 11.
- 11.6 would be scaled up to 12.
- All logs should have a 2-6" trim allowance. Cutting logs without this allowance are termed “cutting scant.”

Log Scaling: Board-Foot Deduction Methods

As the name suggests, board-foot scaling and deduction methods, calculate the net volume in board feet.

1. Diameter reduction
2. Length reduction
3. Diagram reduction

When dealing with defects that are partially hidden or internal it is best to use a diagram where people have worked out typical quantities lost to defects.

Deductions are made as 1" boards but if the defect includes wood lost in the kerf it is not deducted.

Log Scaling: Board-Foot Deduction Methods

For Scribner and other cylinder log rules the standard “squared defect bd ft” deduction formula is given by:

\[
\text{defect} = \frac{w + t + l}{15}
\]

This assumes 1" boards and a ¼" kerf: w = width of defect (in), t = thickness (in), and l = length (ft).

The “15” in the denominator accounts for the wood lost to the kerf → 20% of gross board feet.
Log Scaling: Board-Foot Deduction Methods

- No defect – no deduction
- Length-reduction
- Diameter reduction
- Squared-defect reduction
- Pie-cut or Length-reduction

Log Scaling: Cull Percent Deduction Methods

Board-foot deduction methods require a new formula for each defect. A more general approach is achieved by deducting a percentage of the total log volume.

This cull percentage method was developed by L.R. Grosenbaugh.

Rule 1 – cull percent = length of defective section / L (L is length of log in ft)
Rule 2 – cull percent = (length of defective section / L) x (angle of defect / 360)
Rule 3 – cull percent = (maximum departure - 2") / d (d is diameter of log, inches)
Rule 4 – cull percent = (length of deflecting section / L) x (maximum deflection / d)
Rule 5 – cull percent = (major x minor) / (d-1)² x (length of defect / L)

Source: MTU FW 2050 lecture notes / Avery and Burkhart 5th Edition
Log Rules: Measurements

In all western regions of the US Forest Service (except parts of OR, WA, and AK), the maximum scaling length is 20 feet. 40 feet is standard in western OR and WA.

If the log length exceeds 20 feet it is usually divided into two logs of similar size. Taper should be taken into account to minimize the impact on the larger logs.

The US Forest Service uses Scribner Decimal C Log Rule, the International ¼ Inch log rule, or the Smalian cubic volume rule (36 CFR 223.3)

Measuring log lengths when sweeps and crooks are present is achieved by measuring the horizontal distance.

If a log length exceeds the point where the minimum diameter occurs, the log length ends at that point (i.e., it assumes the bucking was done correctly).

Only deduct defects that penetrate the scaling cylinder.

Defects: Defect Tables

Sap rot: deduct the full %
Weather checks: deduct half the % if straight defect and full % of spiral
If defect > 60%: Log is non-saw with no defect
Example: A 32’ small end diameter log has rot averaging 1.5’ in depth affecting the whole circumference.

Total defect depth (2 sides) = 3’

Total log defect = 18%

Sap rot and weather checks: deduct the full %
If defect > 66%, Log is non-saw with no defect

Example: A 20’ small end diameter log has weather checks averaging 4’ in depth affecting the whole circumference.

Total defect depth (2 sides) = 8’

Log is a non-saw log with no defect
The Scribner Decimal C log rule cheat sheet allows you to quickly deduct defect from the estimated log volume.

Example:
A 20 foot log with 16” diameter with no defect = 200 bd ft
If the same log has a 10” diameter defect affecting 15% of the log, then the deduction = 130 (x 0.15) = 26 bd ft
Net Scale = Gross – Defect Scale = 200 – 26 = 174 bd ft