# Sawmill Short Course
# Log Inputs – Measurement & Conversion Factors

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# Topics to be discussed

1. Common log measurements
2. Scaling logs
3. Conversion factors for log and lumber measurements
4. Value added opportunities in grading lumber

# Common Log Measurements

- Board Foot
- Cubic foot
- Stacked (Cords)
- Linear foot
- Weight

# Board Foot

- Defined as a board containing 144 cubic inches of sawed lumber or the equivalent of a board 12 inches long, 12 inches wide, and 1 inch thick

  Board footage calculation (lumber)

  - Softwood lumber: Use nominal dimensions
  - Hardwood lumber: Use nominal thickness and actual width

# Cubic Foot of Wood

- Defined as a solid piece of wood that is 1 foot long, 1 foot wide, and 1 foot thick
  - This unit is considered the most accurate in common use
  - Does not allow for sawkerf, slabs edgings, shrinkage, bark, or sawing method
  - Pulpwood and salvage materials often measured in cubic feet or cunits (100 cubic feet)

# Cords

- Defined as a stack of wood that occupies a volume of 128 cubic feet

  For example, a pile of wood 4 feet tall by 4 feet by 8 feet long is one cord

  A pile of wood that occupies 160 cubic feet is called a long cord

# Linear Foot of Wood

- A wood member or log of variable width and thickness that is one foot in length

  For example, slabs (both edged and unedged) are often sold by the linear foot

# Wood Weight

Usually measured in tons

- Weigh truck empty and fully loaded, subtracting weight of truck from gross (loaded) weight.
- Pulpwood, southern yellow pine logs, and some hardwood logs (chipwood)

# Scaling Logs

- Board foot log rules
- Cubic foot scaling
- Weight scaling

# Board Foot Log Rules

- The three most commonly used board foot log rules are:

1. Scribner Decimal C
2. International (saw kerf ¼ inch)
3. Doyle

    - The International Rule is most precise, but the Scribner Decimal C is more commonly used
    - In the Rocky Mountain Region, Doyle's log rule is only used in eastern Kansas and Nebraska

# Log Scaling Assumptions

- The log is a cylinder
  - Cylinder diameter equals inside bark diameter at the small end of log
  - Cylinder length equals log length
- Logs are cut into boards one inch thick
- Saw blade thickness (kerf) varies from 1/8 to 3/8 inches
- Boards are utilized to the specified minimum width
- The minimum board length equals log length
- The log if free of defects

# Log Rules – Step Functions

Scribner decimal C log rule
(In tens - i.e., 0 omitted)

SOURCE: USDA-Forest Service Misc. Publication 225)

| Dia. (in.) | Contents in Bd. Ft. of Logs of Length (feet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 6 | 0.5 | 0.5 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| 7 | 0.5 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 |
| 8 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 |
| 9 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 |
| 10 | 2 | 3 | 3 | 3 | 4 | 6 | 6 | 7 | 8 | 9 |
| 11 | 2 | 3 | 4 | 4 | 5 | 7 | 8 | 8 | 9 | 10 |
| 12 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 13 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 15 |
| 14 | 4 | 6 | 7 | 9 | 10 | 11 | 13 | 14 | 16 | 17 |
| 15 | 5 | 7 | 9 | 11 | 12 | 14 | 16 | 18 | 20 | 21 |
| 16 | 6 | 8 | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| 17 | 7 | 9 | 12 | 14 | 16 | 18 | 21 | 23 | 25 | 28 |
| 18 | 8 | 11 | 13 | 16 | 19 | 21 | 24 | 27 | 29 | 32 |
| 19 | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 |
| 20 | 11 | 14 | 17 | 21 | 24 | 28 | 31 | 35 | 38 | 42 |
| 21 | 12 | 15 | 19 | 23 | 27 | 30 | 34 | 38 | 42 | 46 |
| 22 | 13 | 17 | 21 | 25 | 29 | 35 | 38 | 42 | 46 | 50 |
| 23 | 14 | 19 | 23 | 28 | 33 | 38 | 42 | 47 | 52 | 57 |
| 24 | 15 | 21 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 61 |
| 25 | 17 | 23 | 29 | 34 | 40 | 46 | 52 | 57 | 63 | 69 |
| 26 | 19 | 25 | 31 | 37 | 44 | 50 | 56 | 62 | 69 | 75 |
| 27 | 21 | 27 | 34 | 41 | 48 | 55 | 62 | 68 | 75 | 82 |
| 28 | 22 | 29 | 36 | 44 | 51 | 58 | 65 | 73 | 80 | 87 |
| 29 | 23 | 31 | 38 | 46 | 53 | 61 | 68 | 76 | 84 | 91 |
| 30 | 25 | 33 | 41 | 49 | 57 | 66 | 74 | 82 | 90 | 99 |
| 31 | 27 | 36 | 44 | 53 | 62 | 71 | 80 | 89 | 98 | 106 |
| 32 | 28 | 37 | 46 | 55 | 64 | 74 | 83 | 92 | 101 | 110 |
| 33 | 29 | 39 | 49 | 59 | 69 | 78 | 88 | 98 | 108 | 118 |
| 34 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 |
| 35 | 33 | 44 | 55 | 66 | 77 | 88 | 98 | 109 | 120 | 131 |
| 36 | 35 | 46 | 58 | 69 | 81 | 92 | 104 | 115 | 127 | 138 |
| 37 | 39 | 51 | 64 | 77 | 90 | 103 | 116 | 129 | 142 | 154 |
| 38 | 40 | 54 | 67 | 80 | 93 | 107 | 120 | 133 | 147 | 160 |
| 39 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 | 154 | 168 |
| 40 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 | 166 | 181 |
| 41 | 48 | 64 | 79 | 95 | 111 | 127 | 143 | 159 | 175 | 191 |
| 42 | 50 | 67 | 84 | 101 | 117 | 134 | 151 | 168 | 185 | 201 |
| 43 | 52 | 70 | 87 | 105 | 122 | 140 | 157 | 174 | 192 | 209 |
| 44 | 56 | 74 | 93 | 111 | 129 | 148 | 166 | 185 | 204 | 222 |
| 45 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 | 209 | 228 |
| 46 | 59 | 79 | 99 | 119 | 139 | 159 | 178 | 198 | 218 | 238 |
| 47 | 62 | 83 | 104 | 124 | 145 | 166 | 186 | 207 | 228 | 248 |
| 48 | 65 | 86 | 108 | 130 | 151 | 173 | 194 | 216 | 238 | 260 |
| 49 | 67 | 90 | 112 | 135 | 157 | 180 | 202 | 225 | 247 | 270 |
| 50 | 70 | 94 | 117 | 140 | 164 | 187 | 211 | 234 | 257 | 281 |

Diameter given is for the small end of the log measured inside bark.

# Merchantability Guidelines

Guidelines vary by region:

- The minimum merchantable length is 6 feet, but the minimum can vary from 6 to 16 feet
- Minimum small end diameter is usually 5 to 8 inches
- Minimum percentage of gross scale remaining after scaling is 33% for valuable coniferous and 50% for less valuable species

# Defect Deductions

Defect types:

- Mechanical
- Biological
- Physical

# Defect Classifications (Region 2)

1. Interior defects
2. Side defects
3. Defects from curve and sweep
4. Defects from crotches
5. Defects from excessive knots

# Methods of Estimating Defect Deductions

Four main methods:

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

# Squared Defect Method

- Defective area enclosed in a square
- For Scribner Decimal C:

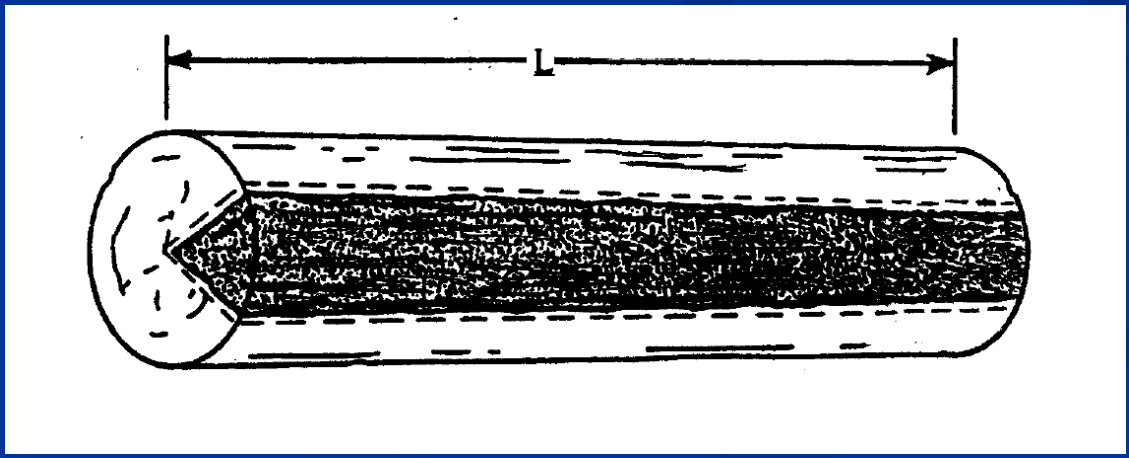
$$D = \frac{W'' \times H'' \times L'}{15}$$

Where: W = Width of defect in inches (plus 1" for waste)
H = Height of defect in inches (plus 1" for waste)
L = Length of defect
D = Deduction in board fee

- Commonly used for internal defects such as rots and heart checks

# Pie-cut Method

- Used when a defect is deep and pie shaped, contained within a sector of a circle
- The deduction has the same relationship to total scale as the sector does to the circle
- Deduction estimates of 1/8, 1/4, 1/3, 1/2, or 2/3 are used
- Defects that this method applies well to include catfaces, fire scars, grubworm holes, and rotton knots



# Length Deduction Method

- Used when defects result in lumber shorter than log length
- It should be used when the deduction for squared defect exceeds the scale of the log length
- Such defects may include sweep, fire scar, knot clusters, large burls, breaks, crotches, massed pitch, and rot

# Diameter Deduction

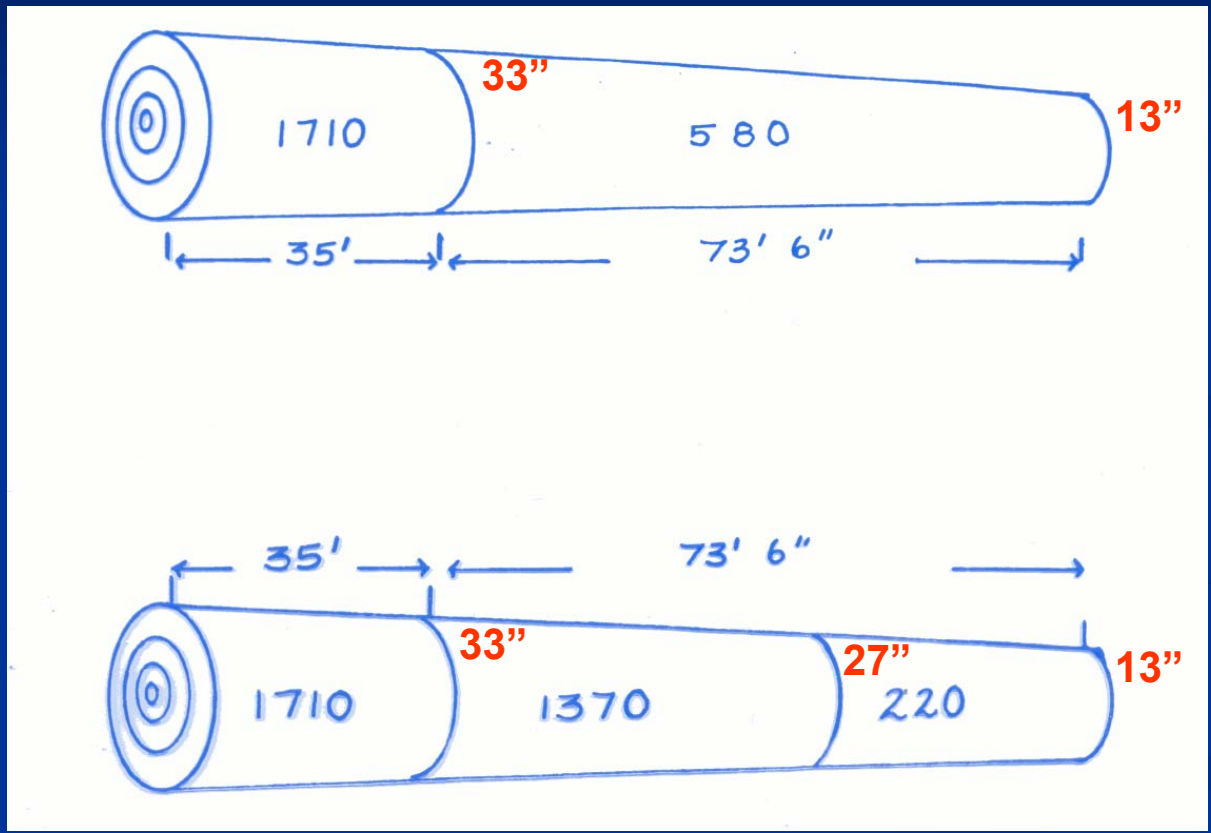
- Involves reducing the scaling diameter of the log
- It is used for defects such as sap rot, weather checks, shallow cat faces, perimeter rings, and excessive knots
- Example: A log with sap rot measures 12” in diameter. The rotten sapwood is 1” thick. The gross diameter of the log is decreased by 2”, with a net diameter and scale of a 10” diameter log.

# Bucking Logs for Scale (Value)

Bucking objectives:

- Cut logs to mill specifications
- Maximize value of logs cut from stem
- Minimize waste

# The Effect of Bucking Decisions on Log Scale (Volume)




Gross Volume (Scribner)
= 2290 Board feet

Gross Volume (Scribner)
= 3300 Board feet

# Cubic Foot Measure

- Cubic foot rules are based on formulae
- The log is consider to be a cylinder having a scaling diameter equal to the diameter inside bark at the log center
- Log volume is equal to the basal area in square feet at the log's center multiplied the log length
- Common cubic foot rules are:
  - Smalian Rule
  - Two-end Conic Rule
  - Sub-Neiloid Rule

# Smalian Rule

- The average basal area is estimated by measuring diameter inside bark at both log ends, computing basal area for both diameters, and then multiplying the average of the two basal areas by the log length

$$\text{Cubic foot volume} = \frac{(\text{Small end BA} + \text{Large end BA})}{2} \times \text{Log length}$$

# Two-end Conic Rule

- The log is considered to be a frustrum of a cone

$$\text{Cubic foot volume} = 0.005454L \times \frac{[D^2(SE) + D^2(LE) + D(SE) + D(LE]}{3}$$

- Relatively new rule provided as an option by the Columbia River Log Scaling and Grading Bureau

# Sub-Neiloid Rule

- Used where logs to be scaled have a shape that more closely approaches the frustrum of a neiloid

$$\text{Cubic foot volume} = 0.005454L \times \frac{[D(SE) + D(LE]^2}{2}$$

- This rule has been used on a more limited basis

# Is there a best system? – The case for using cubic volume

- Change in length/change in volume criteria
- Ability to account for secondary products
- Limiting variations in predicted lumber outputs

# Weight Scaling

- Typically used for small diameter low value logs
- Relative to stick scaling, weight scaling is quick and easy
- Weight can be converted to an equivalent board foot or cord volume using weight scale factors

# Benefits of Weight Scaling

- Reduced scaling costs
- Requires less handling of logs
- Encourages more efficient loading and prompt delivery of logs after harvesting

# Disadvantage of Weight Scaling

- This method does not consider size, log quality or species mix, log diameter, length, or soundness

# Weight Scaling Data Collection

The following load data is typically collected:

- Weights (Gross, tare, and net) in pounds
- Net weight in tons
- Source identities
- Load receipt number
- Destination identification
- Product identification
- Ticket number
- Date and time of scale
- Logger

# Weight Scale Factors

- Can use standard weight-scale factors or many companies develop their own to convert weight to an equivalent board foot or cord volume
- Weight scale factors vary with timber quality, moisture content, and mill efficiency
- Because forest site conditions affect specific gravity, weight scale factors also vary with different geographic location

# Example: Weight Scaling Factor

Ponderosa pine:

Assume:

- Specific gravity = 0.38
- Moisture content = 80%
- 1 cunit = Approximately 1.117 cords
- 1 MBF (log scale) = Approximately 2 cords

4268 pounds or 2.13 tons per cunit of solid wood

3821 pounds or 1.91 tons per cord wood

7642 pounds or 3.82 tons per MBF

# Estimating the Number of Sample Truckloads Needed to Achieve a Specified Precision of Sale-wide Estimates

$$n = \frac{1}{(PE/CV)^2 (1/t^2)+1/N}$$

Where:

n = Number of truckloads in sample

N = Estimated truckloads in sale

PE = $(E/\bar{x}) \times 100\%$

CV = $(S/\bar{x})$

$\bar{x}$ = Mean of ratio in cubic feet of wood per pound of wood and bark

t = Student's t ratio, for n larger than 25, t is approximately equal to 2

E = One-half the width of the desired confidence interval (The precision of the sample estimate of the mean of ratio in cubic feet of wood per pound of wood and bark)

From USFS Research Paper RM 311 by Markstrom & King

# Conversion Factors for Log/Lumber Measurements

Board foot measurements:

1 board foot = 144 cubic inches or 1/12 cubic feet of solid wood

1 MBF = 1000 board feet

1 MBF = 83.33 cubic feet solid wood

1 MBF = Approximately 2 cords of wood

# Conversion Factors for Log/Lumber Measurements

Cubic foot measurements:

1 Cunit = 100 cubic feet of solid wood

1 Cunit = 1200 board feet

1 Cunit = Approximately 1.117 cords

# Board Foot (Scale) to Cubic Volume

***Table 4.*—Approximate board-foot and cubic-foot conversions.**
(Shaded entries are those used as examples in the text).[a]

| Westside Scribner scale[b] | | | Eastside Scribner scale[c] | | |
|---|---|---|---|---|---|
| Log diameter (in) | Bd ft per cubic ft (gross) | Cubic ft per 1,000 bd ft | Log diameter (in) | Bd ft per cubic ft (gross) | Cubic ft per 1,000 bd ft |
| 6 | 3.32 | 301 | 6 | 3.59 | 279 |
| 8 | 3.41 | 293 | 8 | 4.44 | 225 |
| ***10*** | ***3.96*** | ***253*** | ***10*** | ***5.03*** | ***199*** |
| ***12*** | ***4.52*** | ***221*** | ***12*** | ***5.50*** | ***182*** |
| 14 | 5.00 | 200 | 14 | 5.89 | 170 |
| 16 | 5.41 | 185 | 16 | 6.25 | 160 |
| 18 | 5.75 | 174 | 18 | 6.57 | 152 |
| 20 | 6.03 | 166 | 20 | 6.87 | 146 |
| 22 | 6.26 | 160 | 22 | 7.16 | 140 |
| 24 | 6.45 | 155 | 24 | 7.44 | 134 |
| 26 | 6.62 | 151 | | | |
| 28 | 6.75 | 148 | | | |
| 30 | 6.86 | 146 | | | |

[a] Personal communication, Jim Cahill, research forester, timber quality, USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, OR.
[b] Logs measured using westside Scribner scaling rules.
[c] Logs measured using eastside Scribner scaling rules.

From The Woodland Workbook – Measuring Timber Products Harvested from Your Woodland by Oester and Bowers

# Conversion Factors for Log/Lumber Measurements

Stacked wood measurements:

1 Cord = 128 cubic feet of stacked logs

1 Cord = Approximately 85 cubic feet of solid wood

1 Cord = Approximately 500 board feet (log scale)

# Value-added opportunities in grading small diameter logs

- Log grading basics
- Factors that affect
- Grading strategies for small mills and small diameter logs

# Log Grading

Definition: Classifying logs based on species, length, diameter, and quality as a means of determining value

- Camp run: a mix of saw logs or better quality logs sold at the same price
- As log size increases and quality improves, it becomes more common to sell logs at different prices based on grade

# Factors that Influence Log Grade

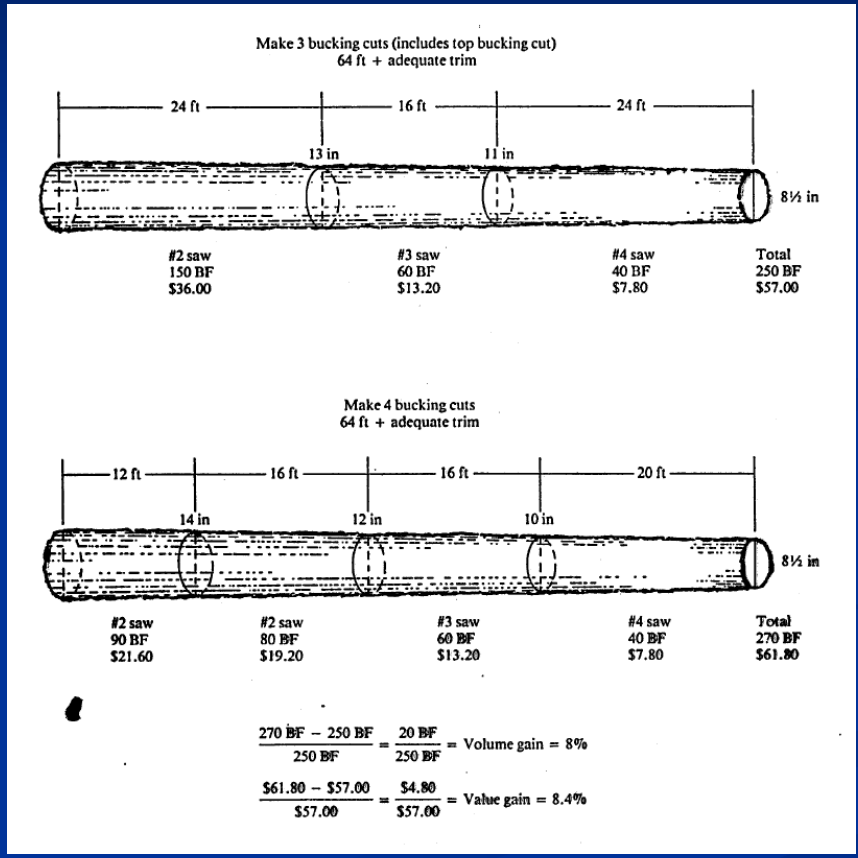
- Species
- Log length
- Log diameter
- Growth rate
- Defects

# Log Grades (Example)

*Table 5.*—Log grades (continued).

| Species and grade | Minimum gross length (ft) | Minimum gross diameter (in) | Required standards for quality, log surface, and minimum merchantable volume |
|---|---|---|---|
| *Ponderosa and sugar pine* | | | |
| Peeler logs | 17 | 30 | Logs produce A-grade veneer and high-grade lumber. Log surface 100% clear of knots. Minimum annual ring count is eight/in. |
| No. 1 sawmill | 16 | 30 | Logs produce D-grade select and better lumber. Log surface 90% clear of knots. Minimum annual ring count is eight/in. |
| No. 2 sawmill | 12 | 24 | Logs produce D-grade select and better lumber. Log surface 75% clear of knots. Minimum annual ring count is eight/in. |
| No. 3 sawmill | 12 | 24 | Logs produce shop-grade and better lumber. Log surface 50% clear of knots. Spacing allows 6 ft between knot whorls, 3 ft between staggered knots. Annual ring count is eight/in. |
| No. 4 sawmill | 12 | 12 | Logs produce No. 2-grade common and better lumber. Knots on log surface allowed up to 2½ inches in diameter. Larger knots are spaced as in No. 3 logs. |
| No. 5 sawmill | 12 | 6 | Logs produce No. 3-grade common and better lumber. |
| No. 6 sawmill | 12 | 5 | Logs do not meet No. 5 requirements (neither diameter nor minimum volume) but produce at least 33⅓% of gross volume in merchantable lumber. |

# The Effect of Bucking Decisions on Log Scale and Grade (Volume and Value)



# Grading strategies for small mills and small diameter logs

- Product diversification, emphasizing value-added products
- Establish criteria for log quality segregation of small logs based on external defects and knot distribution
- Develop log handling systems that can efficiently segregate logs, while minimizing handling costs
- Log grading process may require automated systems with scanning and defect identification capabilities

# Colorado Wood Utilization & Marketing Assistance Center - Contact Information

- Webpage (www.colostate.edu/programs/cowood)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