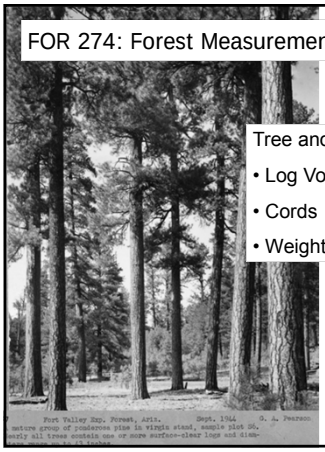
What Do You See?

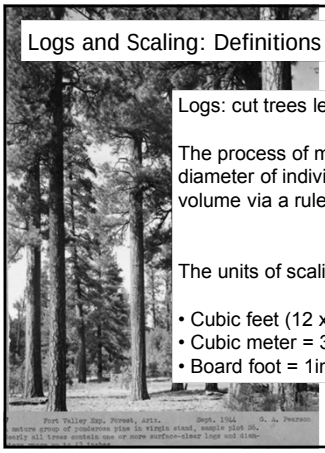
FOR 274: Forest Measurements and Inventory



Tree and Wood Volume

- Log Volumes
- Cords
- Weight Scaling

Logs and Scaling: Definitions



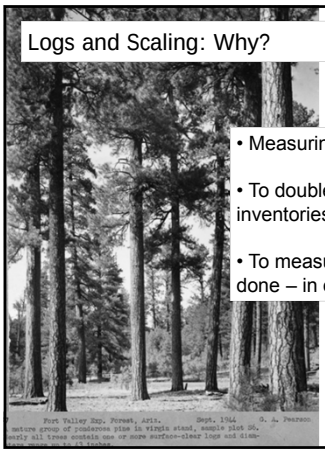
Logs: cut trees lengths of 8ft or more

The process of measuring the length and diameter of individual logs to obtain a volume via a rule is called scaling

The units of scaling measurements are:

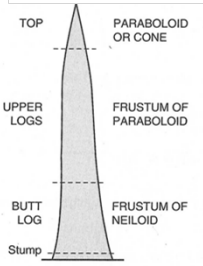
- Cubic feet (12 x 12 x 12 inches)
- Cubic meter = 35.3 cu ft
- Board foot = 1in x 12in x 12in = 144 cu in

Logs and Scaling: Why?



- Measuring Products for Sale
- To double check the projections of inventories
- To measure how much work was done – in order to pay people

Log Volumes: Geometric Solids



Logs are not perfect cylinders!

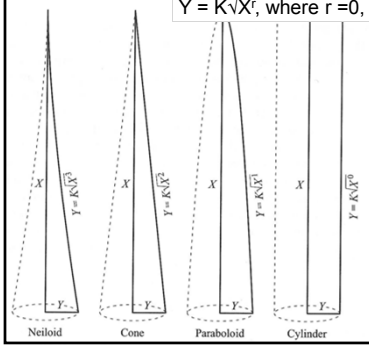
Logs taper from one end to another

Truncated sections of a tree can be approximated as geometric shapes:
- Cone
- Paraboloid
- Neiloid

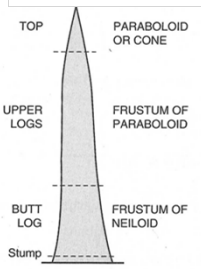
where $B_{1/2}$ = cross-sectional area at log midpoint
B = cross-sectional area at large end of log
b = cross-sectional area at small end of log
L = log length

Log Volumes: Geometric Solids

Geometric tree shapes follow the equation $Y = K\sqrt{X^r}$, where r =0, 1, 2, 3, etc



Log Volumes: Geometric Solids



Volume of any geometric soild
= "average cross-sectional area" * Length

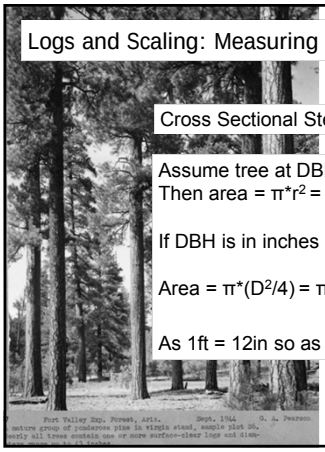
Huber's Cu Volume = $(B_{1/2})$*L

Smalian's Cu Volume = (B+b)/2 * L

Newton's Cu Volume = $(B+4B_{1/2}+b)/6$*L

where $B_{1/2}$ = cross-sectional area at log midpoint
B = cross-sectional area at large end of log
b = cross-sectional area at small end of log
L = log length

Logs and Scaling: Measuring B



Cross Sectional Stem Area or Basal Area

Assume tree at DBH is a circle
Then area = $\pi * r^2 = \pi * (D/2)^2 = \pi * (D^2/4)$

If DBH is in inches and we want area in sq ft:

Area = $\pi * (D^2/4) = \pi * D^2/(4*144) = 0.005454 * D^2$

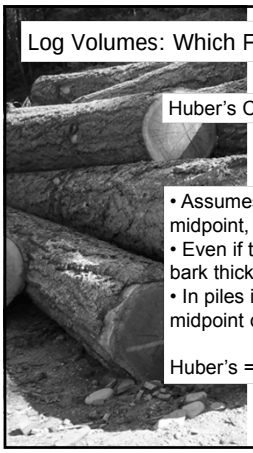
As 1ft = 12in so as squared = 12x12 = 144

Log Volumes: Geometric Solids

Geometric Solid	Equation for Volume V (cubic units)[a]	Equation Number
Cylinder	$V = A_b h$	(6-1)
Paraboloid	$V = \frac{1}{2}(A_b h)$	(6-2)
Cone	$V = \frac{1}{3}(A_b h)$	(6-3)
Neiloid	$V = \frac{1}{4}(A_b h)$	(6-4)
Paraboloid frustum	$V = \frac{h}{2}(A_b + A_u)$ (Smalian's formula)	(6-5)
	$V = A_m h$ (Huber's formula)	(6-6)
Cone frustum	$V = \frac{h}{3}\left(A_b + \sqrt{A_b A_u} + A_u\right)$	(6-7)
Neiloid frustum	$V = \frac{h}{4}\left(A_b + \sqrt[3]{A_b^2 A_u} + \sqrt[3]{A_b A_u^2} + A_u\right)$	(6-8)
Neiloid, cone, or paraboloid frustum	$V = \frac{h}{6}(A_b + 4A_m + A_u)$ (Newton's formula)	(6-9)

[a] A_b, cross-sectional area at base; A_m, cross-sectional area at middle; A_u, cross-sectional area at upper end; h, height or length.

Log Volumes: Which Formula?

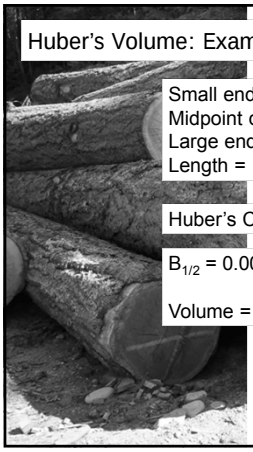


Huber's Cu Volume = $(B_{1/2})$*L

- Assumes average cross-section area is at midpoint, which is rarely true
- Even if true: NEED to measure area within bark thickness, and
- In piles it can be impractical to measure the midpoint diameter

Huber's = Poor Method

Huber's Volume: Example



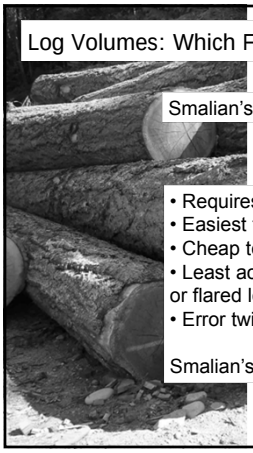
Small end diameter = 6 in
Midpoint diameter = 8 in
Large end diameter = 9 in
Length = 16 ft

Huber's Cu Volume = $(B_{1/2})$*L

$B_{1/2}$ = 0.005454 * (8*8) = 0.349

Volume = 0.349 * 16 = 5.585 cu feet

Log Volumes: Which Formula?

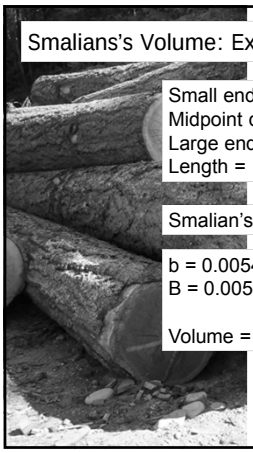


Smalian's Cu Volume = (B+b)/2 * L

- Requires measures at both ends of log
- Easiest to measure
- Cheap to implement
- Least accurate: especially for swollen butts or flared logs
- Error twice as large as Huber's formula

Smalian's = The Compromise Method

Smalians's Volume: Example



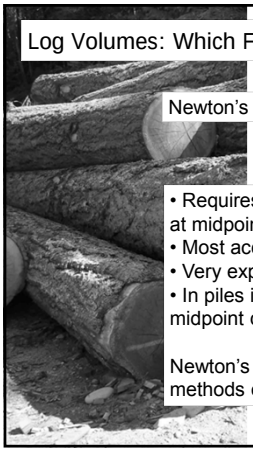
Small end diameter = 6 in
Midpoint diameter = 8 in
Large end diameter = 9 in
Length = 16 ft

Smalian's Cu Volume = (B+b)/2 * L

b = 0.005454 * (6*6) = 0.196
B = 0.005454 * (9*9) = 0.442

Volume = (0.196+0.442)/2*16 = 5.104 cu feet

Log Volumes: Which Formula?

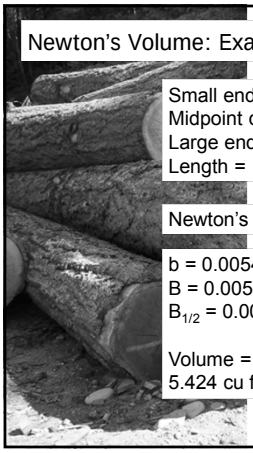


Newton's Cu Volume = $(B+4B_{1/2}+b)/6*L$

- Requires measures at both ends of log and at midpoint
- Most accurate method
- Very expensive and restricted to research
- In piles it can be impractical to measure the midpoint diameter

Newton's = Used to check accuracy of other methods or to develop growth volume curves

Newton's Volume: Example



Small end diameter = 6 in
Midpoint diameter = 8 in
Large end diameter = 9 in
Length = 16 ft

Newton's Cu Volume = $(B+4B_{1/2}+b)/6*L$

b = 0.005454 * (6*6) = 0.196
B = 0.005454 * (9*9) = 0.442
$B_{1/2}$ = 0.005454 * (8*8) = 0.349

Volume = (0.442+(4*0.349)+0.196)/6 * 16 = 5.424 cu feet

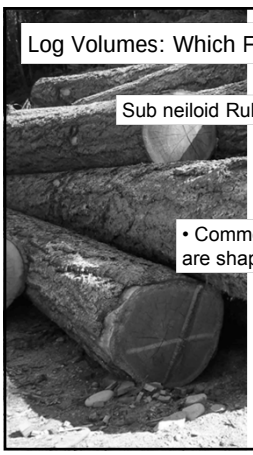
Log Volumes: Which Formula?

2-End Conic Rule = $(0.005454*L)*[(d^2+D^2+d*D)/3]$

d = diameter at small end
D = diameter at large end

- Common rule used by several timber companies
- Accounts for dropped fractions when converting diameters to areas (as in D)

Log Volumes: Which Formula?

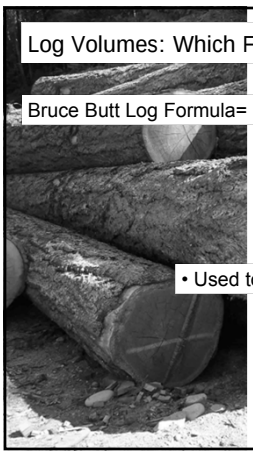


Sub neiloid Rule = $(0.005454)*[(d+D)/2]$

d = diameter at small end
D = diameter at large end

- Common rule used industry when the logs are shaped like the frustum of the neiloid

Log Volumes: Which Formula?



Bruce Butt Log Formula= $(0.005454)*[0.25D^2+0.75d^2)(RL+T)]$

d = diameter at small end
D = diameter at large end
RL = length
T = trim (0.5' per section)

- Used to calculate cubic volume of butt logs

Log Volumes: Which Formula?

For perfect cylinders these eqns are identical

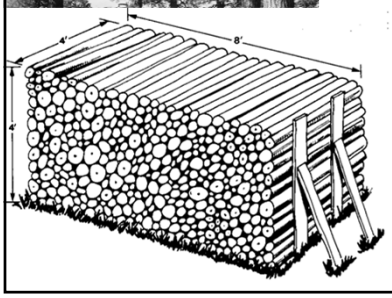
In some cases a constant taper rate can be assumed: e.g. ½ in per 4ft increment

Butt logs: Huber method underestimates by 5% and Smalian method overestimates by 10%

Intermediate logs: Huber method and Smalian are very close to the Newton method

Measuring Stacked Wood: The Cord

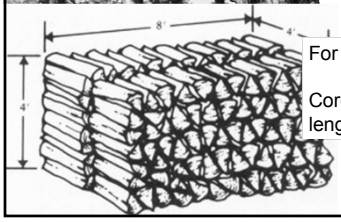
One cord = 4 x 4 x 8 ft = 128 cu ft



Measuring Stacked Wood: The Cord

Cords include: wood, bark, and voids

It is unlikely that:
- wood will be 4ft lengths
- ricks will be 32 sq ft

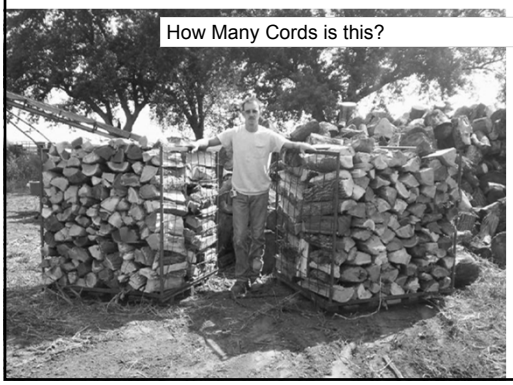


For Feet Measures:

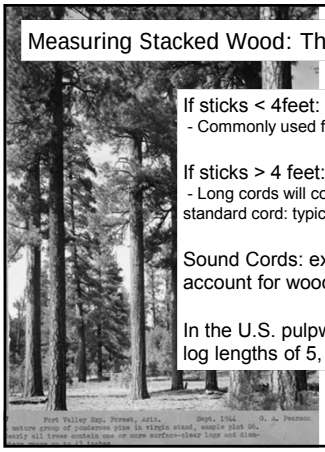
Cords = (width x height x stick length)/128

Measuring Stacked Wood: The Cord

How Many Cords is this?



Measuring Stacked Wood: The Cord



If sticks < 4feet: cord = short cord
- Commonly used for firewood

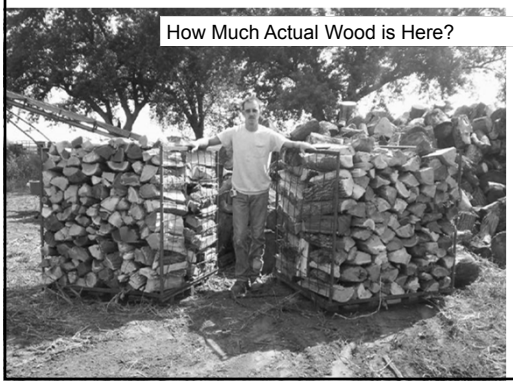
If sticks > 4 feet: cord = long cord
- Long cords will contain more wood than a standard cord: typically: 8x4x5 ft

Sound Cords: extra wood is added to account for wood lost due to defects

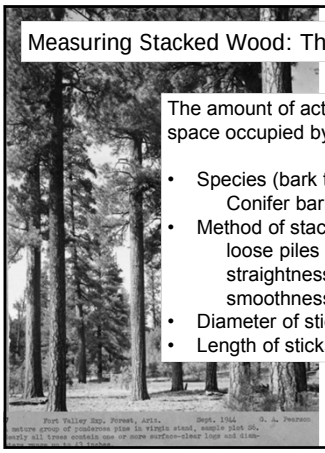
In the U.S. pulpwood commonly is cut into log lengths of 5, 5.25, and 8.33 feet.

Measuring Stacked Wood: The Cord

How Much Actual Wood is Here?



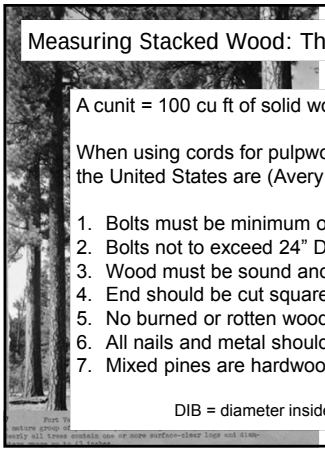
Measuring Stacked Wood: The Cord



The amount of actual wood available in the space occupied by a cord is dependent on:

- Species (bark thickness)
  - Conifer bark ~10-30% of sticks
- Method of stacking
  - loose piles = more air = less wood
  - straightness of bolts
  - smoothness of bolts (knots!)
- Diameter of sticks
- Length of sticks

Measuring Stacked Wood: The Cunit



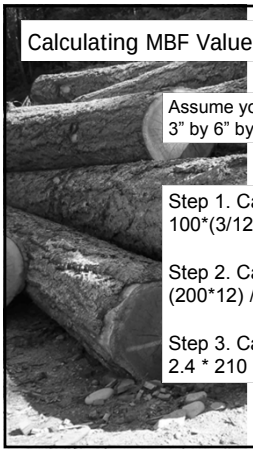
A cunit = 100 cu ft of solid wood

When using cords for pulpwood, typical specifications in the United States are (Avery and Burkhart, 5th Ed):

1. Bolts must be minimum of 4" DIB at the small end
2. Bolts not to exceed 24" DOB at the large end
3. Wood must be sound and straight
4. End should be cut square and limbs trimmed flush
5. No burned or rotten wood
6. All nails and metal should be removed
7. Mixed pines are hardwoods are not acceptable

DIB = diameter inside bark, DOB = diameter outside bark

Calculating MBF Value: An Example



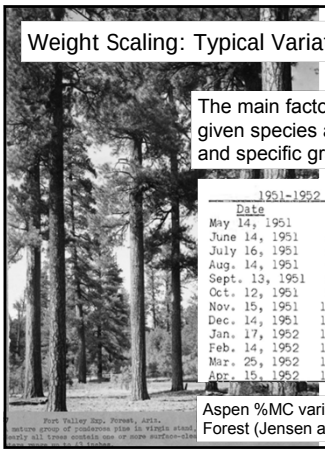
Assume you have 100 pieces of lumber of sizes 3" by 6" by 16' selling at $210 per MBF.

Step 1. Calculate Cubic Feet:
100*(3/12)*(6/12)*16 = 200 cubic feet

Step 2. Calculate MBF:
(200*12) / 1000 = 2.4 MBF

Step 3. Calculate the $ Value:
2.4 * 210 = $504

Weight Scaling: Typical Variations

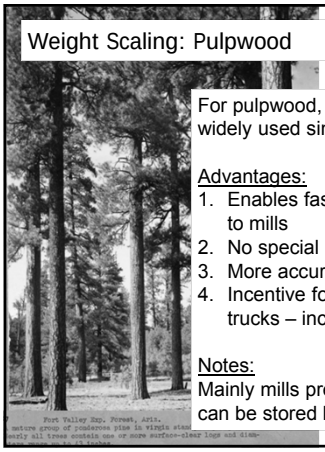


The main factors that affect weight for a given species are: volume, moisture content, and specific gravity

1951-1952		1952-1953	
Date	M.C.	Date	M.C.
May 14, 1951	93.7	June 6, 1952	72.1
June 14, 1951	84.1	July 3, 1953	73.4
July 16, 1951	84.5	July 30, 1952	73.4
Aug. 14, 1951	90.2	Aug. 29, 1952	76.5
Sept. 13, 1951	84.0	Sept. 24, 1952	73.7
Oct. 12, 1951	88.3	Oct. 22, 1952	83.7
Nov. 15, 1951	107.0	Nov. 24, 1952	106.8
Dec. 14, 1951	109.2	Dec. 17, 1952	109.5
Jan. 17, 1952	114.6	Jan. 13, 1953	106.6
Feb. 14, 1952	108.6	Feb. 10, 1953	107.5
Mar. 25, 1952	114.9	Mar. 10, 1953	109.4
Apr. 15, 1952	104.9	Apr. 13, 1953	101.8

Aspen %MC variations in the Cloquet Experimental Forest (Jensen and Davis, 1953)

Weight Scaling: Pulpwood



For pulpwood, weight scaling has been widely used since the mid 1950s.

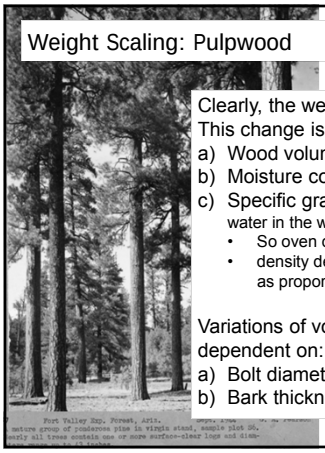
Advantages:

1. Enables fast delivery of freshly cut wood to mills
2. No special handling is needed
3. More accurate than manual scaling
4. Incentive for better piling of wood on trucks – increases volume to mills

Notes:

Mainly mills prefer freshly cut material as it can be stored longer before it deteriorates

Weight Scaling: Pulpwood



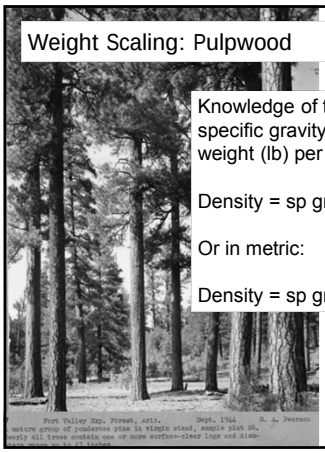
Clearly, the weight of logs change over time. This change is dependent on:

a) Wood volume
b) Moisture content
c) Specific gravity: density of sample /density of water in the wood
   - So oven dry samples
   - density decreases as you move up the stem as proportionally less heartwood

Variations of volume within a cord are dependent on:

a) Bolt diameter, length, and quality
b) Bark thickness

Weight Scaling: Pulpwood



Knowledge of the moisture content and specific gravity allows you to calculate weight (lb) per cubic foot as:

Density = sp gravity x 62.4 (1+ %MC/100)

Or in metric:

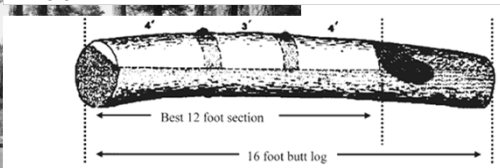
Density = sp gravity x 1.00 (1+ %MC/100)

Weight Scaling: Sawlogs

What limitations would exist in applying weight scaling to sawlogs?

1. Weight is not the same as quality

Price adjustments have to be made to account for variations in log grade, size, and shape.



Weight Scaling: Sawlogs

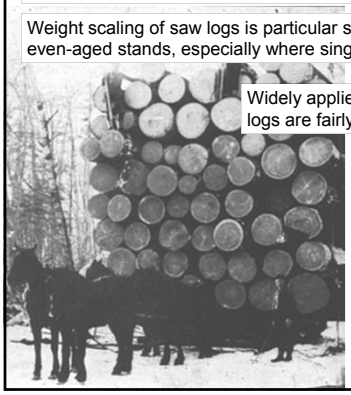
What limitations would exist in applying weight scaling to sawlogs?

2. Weight is not a measure of quantity

Lots of small diameter logs (less lumber) can weigh the same as less large diameter logs

Weight Scaling: Sawlogs

Weight scaling of saw logs is particular suited for plantations or other even-aged stands, especially where single species are harvested.



Widely applied in southern pine logs as logs are fairly uniform in size and quality

Species	Weight (1lb)
Jack pine	11,500
Loblolly pine	12,400
Longleaf pine	11,100
Red maple	11,900
Sugar maple	12,900
Red oak	14,800
Yellow birch	13,200
chestnut	12,600
Balsam fir	10,400
Douglas fir	8,700
hickory	14,700
Black walnut	11,900