

Understanding Weight Scaling by Species, Season, and Moisture Content

Wisconsin Society of American
Foresters Northeast Chapter

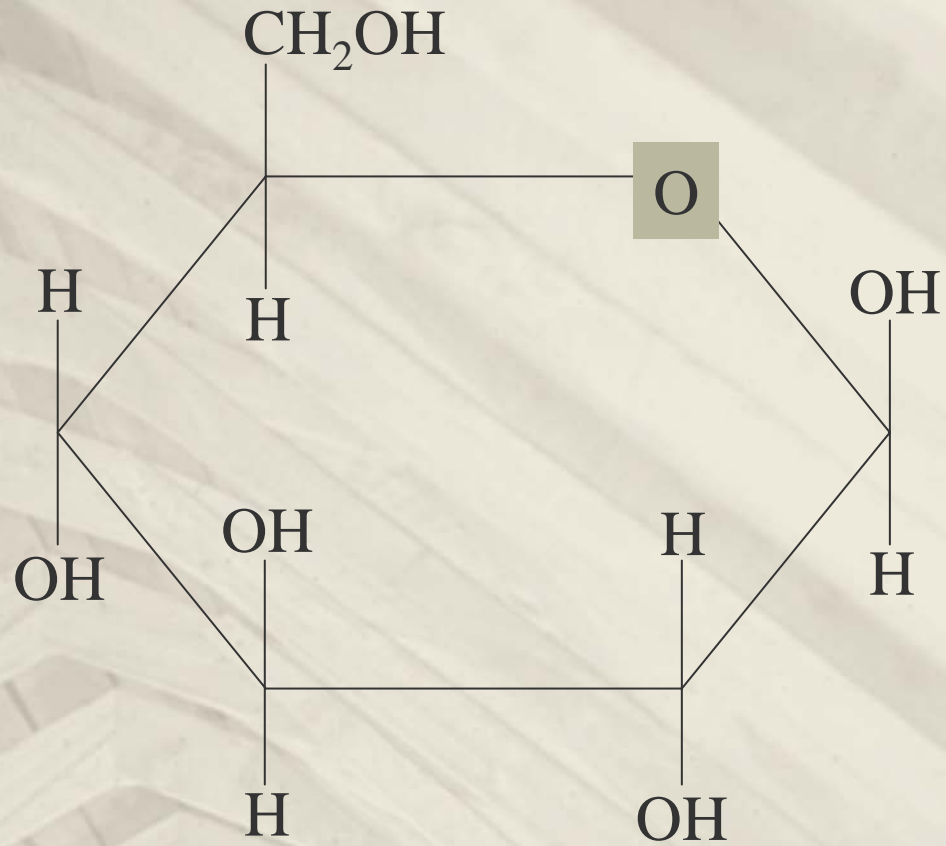
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September 10, 2008

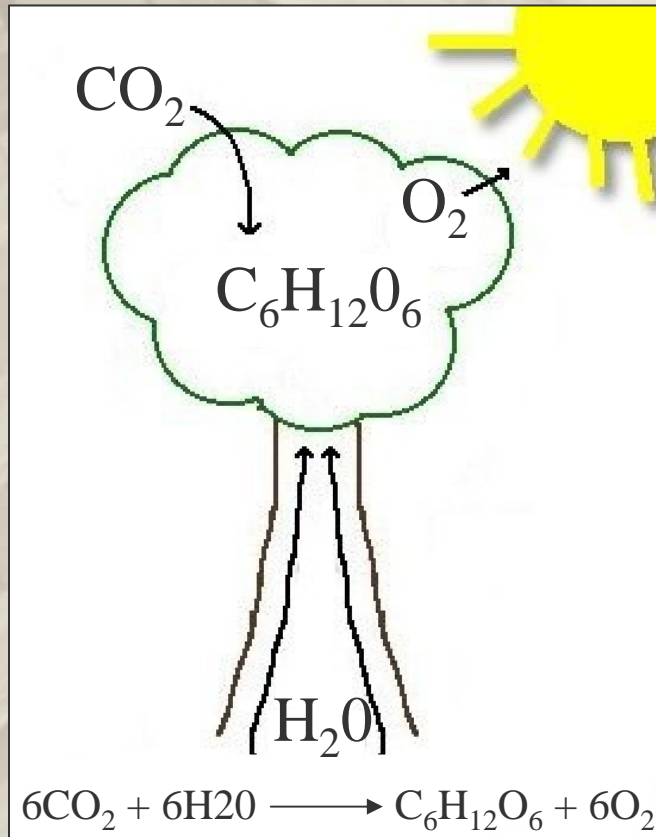
- Wood Structure and Weight
- Wood Structure and Water
- Species, Water, and the Seasons

Wood Structure and Weight



glucose

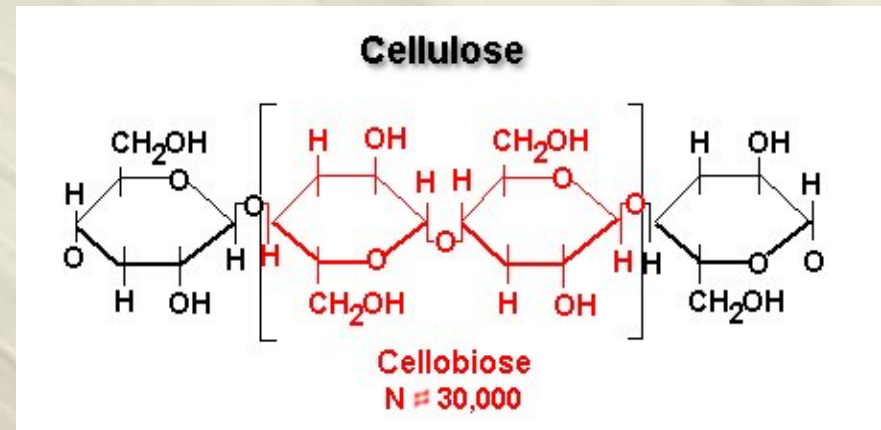
How is wood manufactured in nature?



(From Bowyer & Smith)



glucose anhydride



(From Bowyer & Smith)

Chemical Components

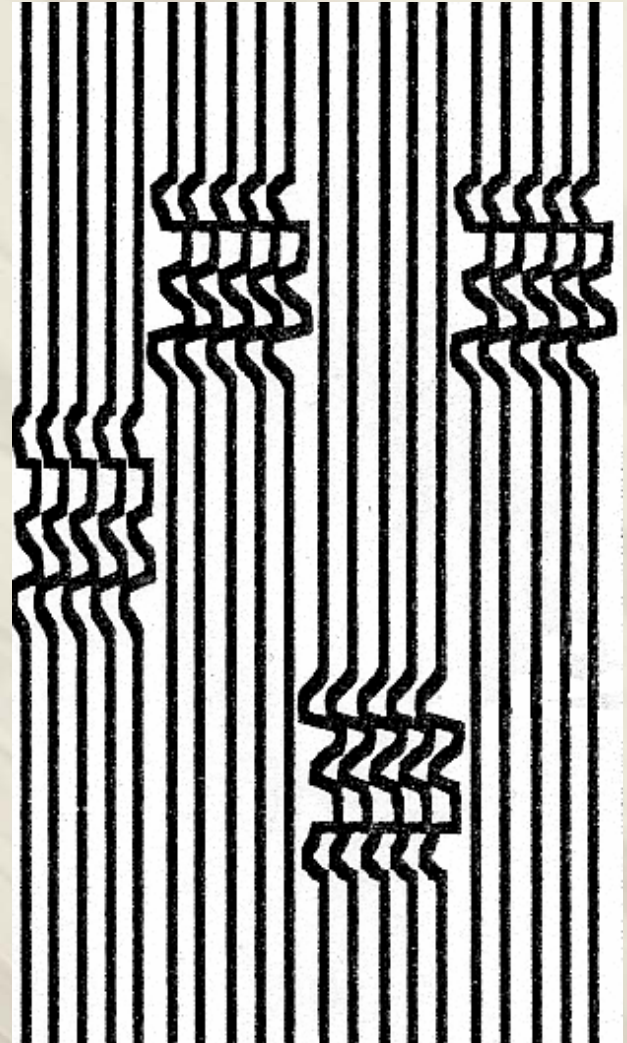
Organic Makeup of Wood (% of Oven-dry Weight)

	Cellulose	Hemicellulose	Lignin
Hardwoods	40 to 44	15 to 35	18 to 25
Softwoods	40 to 44	20 to 32	25 to 35

(From Bowyer & Smith)

Cellulose

- Polymer
 - 14,000
- hydrogen bonding
- 2 regions of cellulose
 - crystalline, ~70%
 - amorphous, ~30%
- water interaction

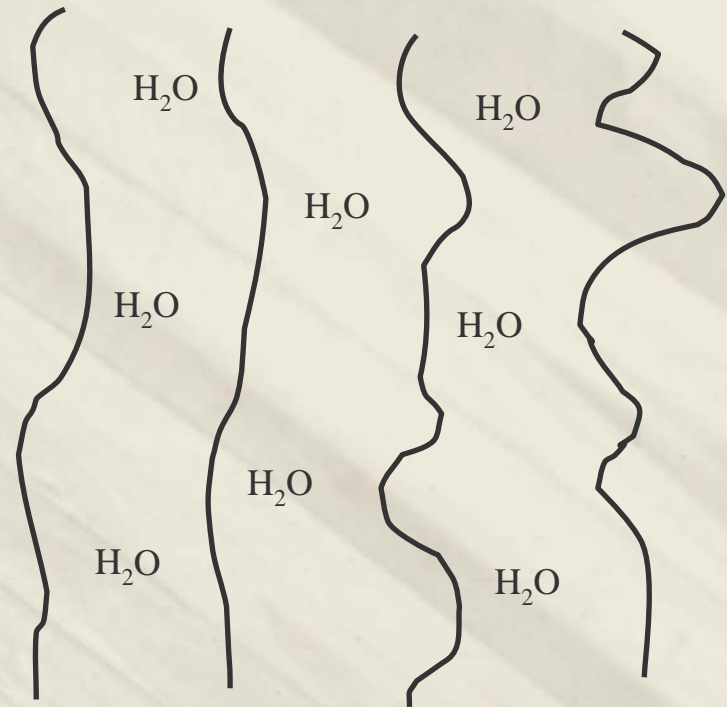


(From Kamke)

Amorphous Areas and Water Interaction

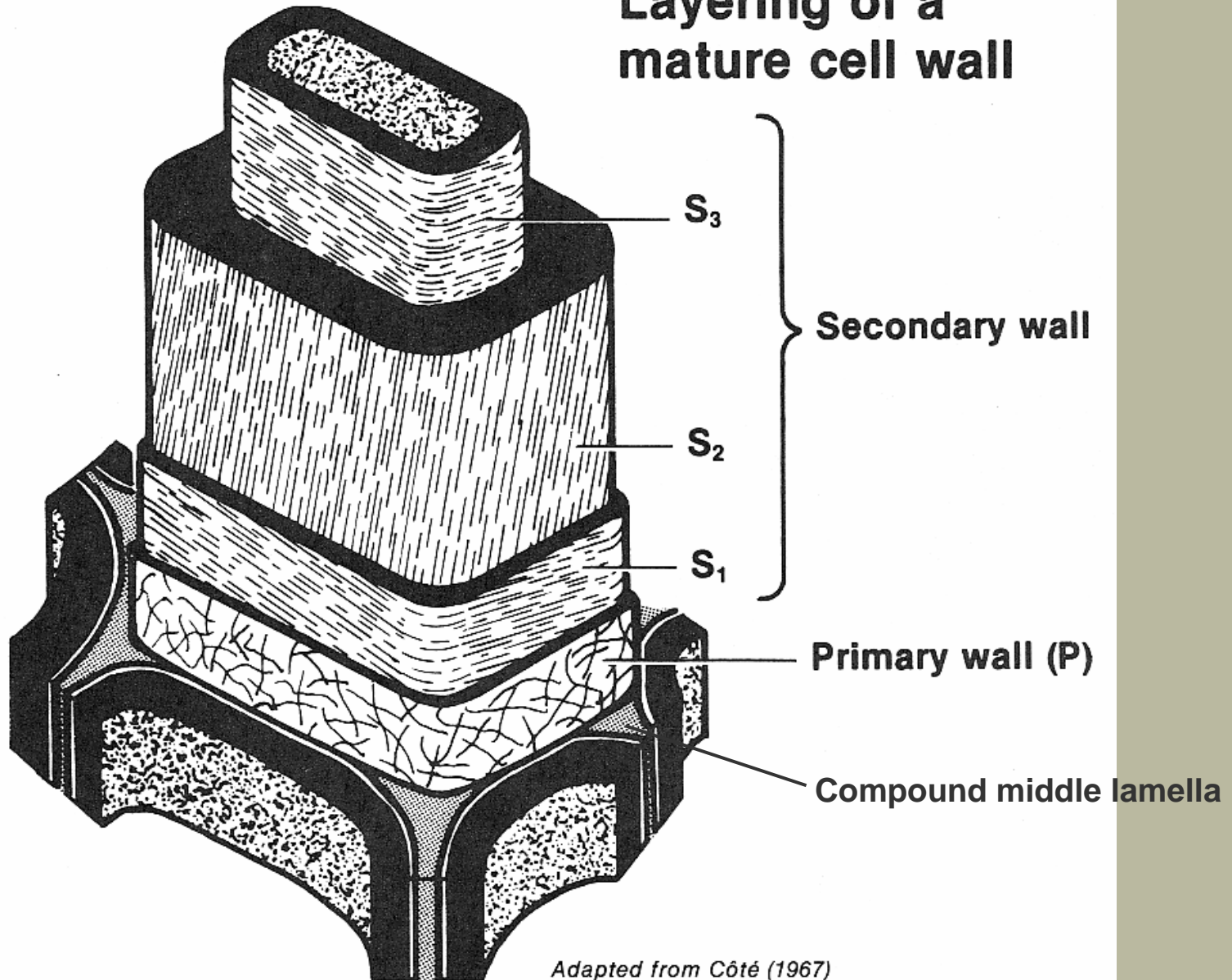


amorphous cellulose region



amorphous cellulose region
water interaction

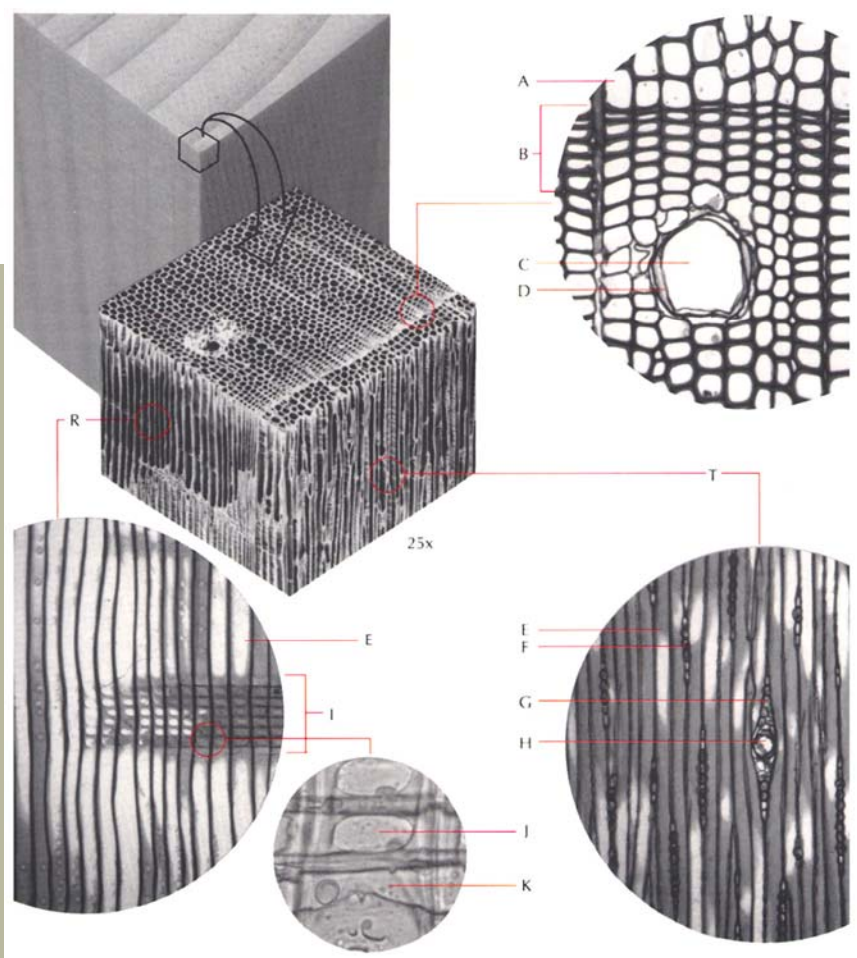
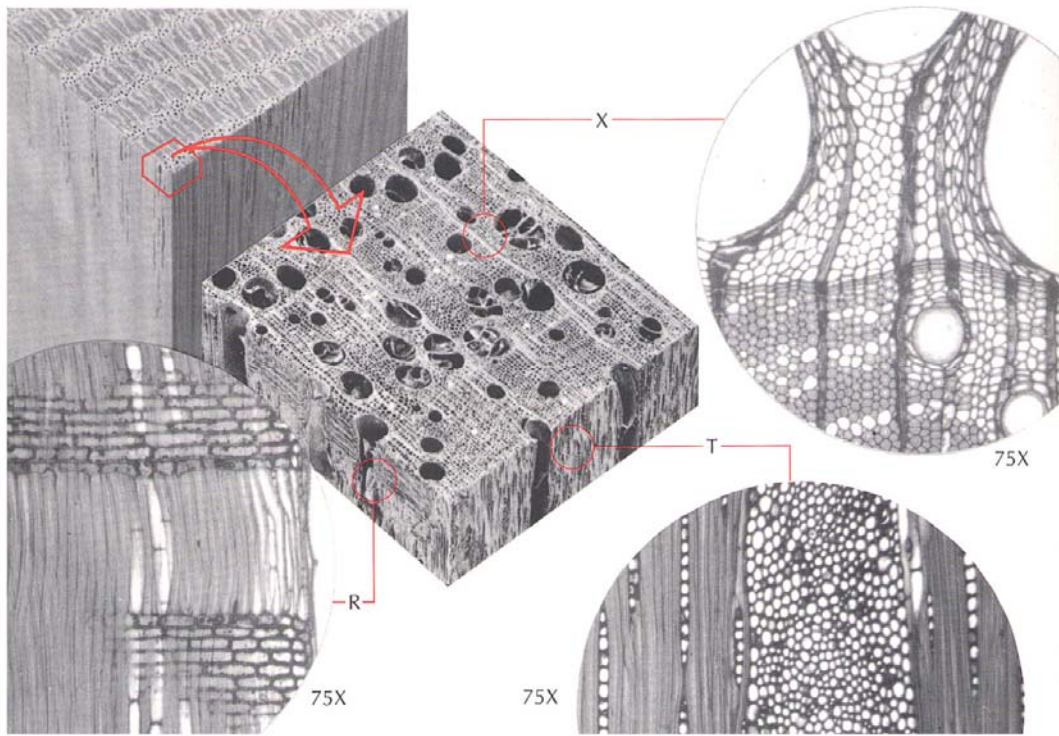
Layering of a mature cell wall



Adapted from Côté (1967)

What does wood weigh?

- Wood cell wall substance weighs 1.5 g/cm^3 or 19.3 lbs/ft^3
- This holds true for all species
- Why does trembling aspen weigh less than white oak?



(From Hoadley)

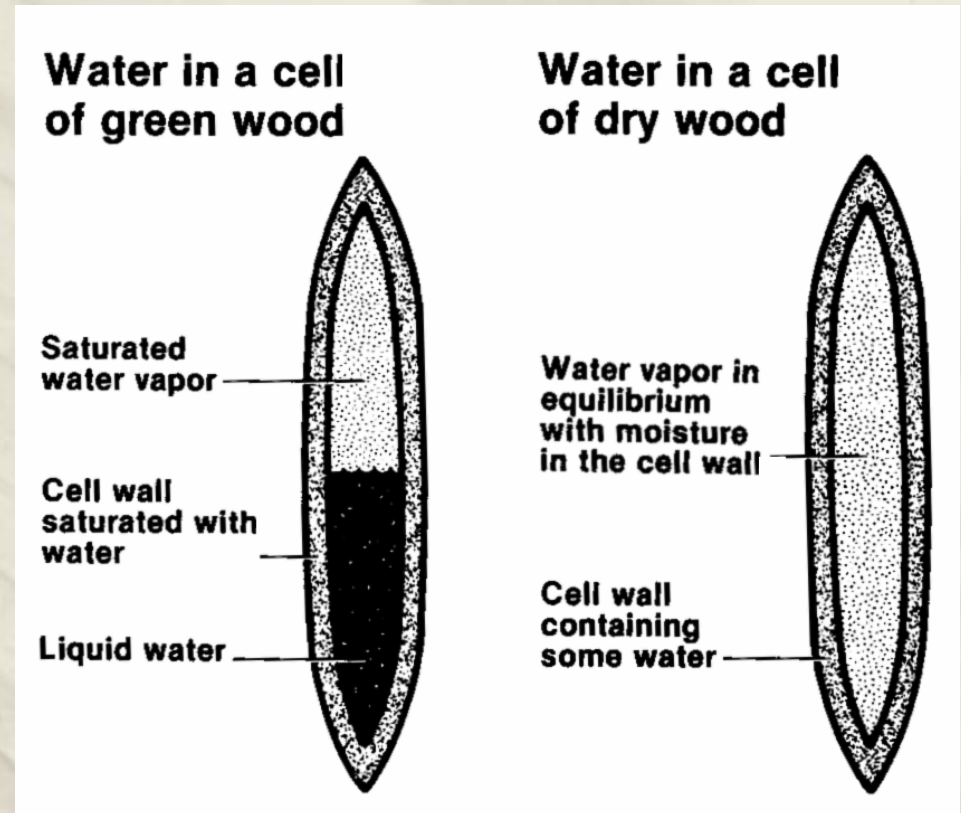
Wood Structure and Water

Amount of Water

- Xylem: water commonly makes up over $\frac{1}{2}$ the total weight
- The weight of water is often equal to or greater than the weight of the dry wood substance

Location of Water

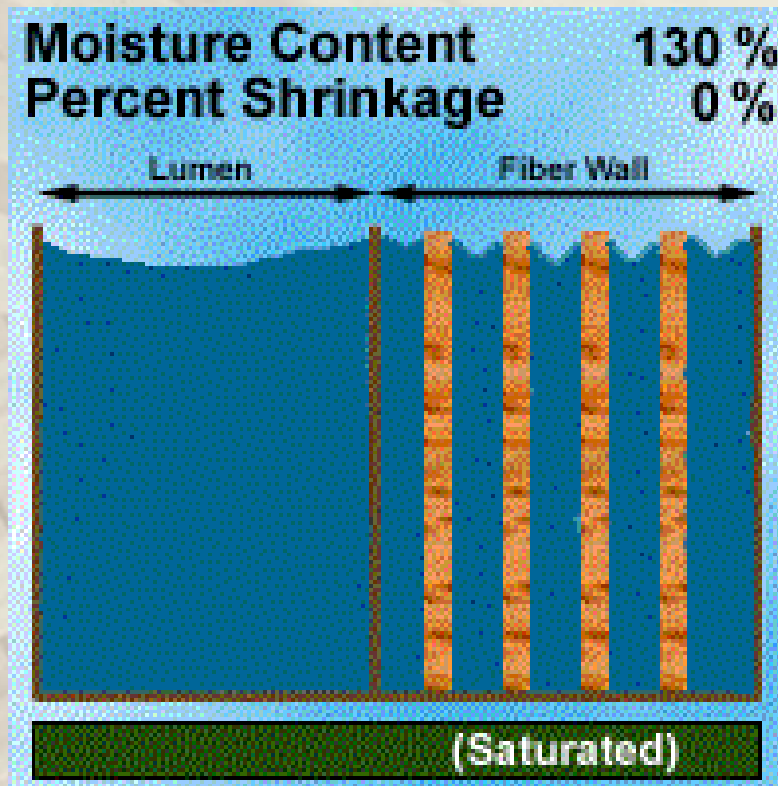
- **Parts of the cell**
 - cell lumen
 - cell wall
- **Free Water**
- **Bound Water**



Fiber Saturation Point (FSP)

- Defined: the point at which all liquid water is removed from the cell lumen, but the cell wall is still fully saturated
- FSP is around 30% moisture content
- Below this point, wood properties are altered by changes in moisture content
- Once dried below FSP, wood must come in contact with liquid water to move above the FSP and reacquire liquid water in the lumen

Fiber Saturation Point (FSP)



Species, Water, and the Seasons

Moisture differences within a tree's parts

Species	Stem wood	Stem bark	Stem	Branch wood	Branch bark	Branch	Tree
	----- <i>Percent</i> -----						
Ash, green	47.4 (3.9)	75.9 (8.6)	51.4 (4.2)	46.9 (3.7)	86.0 (10.2)	55.6 (3.9)	51.9 (4.2)
Elm, winged	65.6 (5.3)	76.0 (7.8)	66.7 (4.9)	61.0 (6.3)	79.5 (7.8)	65.3 (5.2)	66.5 (4.9)
Maple, red	69.9 (2.9)	74.4 (2.6)	70.5 (2.5)	73.7 (4.9)	89.4 (6.9)	77.1 (4.6)	71.5 (2.3)
Oak, northern red	69.7 (8.1)	55.7 (14.5)	66.8 (8.0)	59.2 (7.2)	62.6 (5.6)	60.2 (6.4)	66.0 (7.6)

Moisture: Winter vs. Summer

Species	Period	Basis	Mean Moisture Content		
			Wood	Bark	Wood and Bark
Black spruce ¹	Winter	No. of loads	Percent	Percent	Percent
		82	71.6 (69.2-74.0) ²	81.4 (78.7-84.2)	72.4 (70.1-74.7)
Jack pine	Summer	19	85.2 (76.9-93.5)	75.4 (63.7-87.1)	84.2 (76.1-92.3)
	Winter	13	89.4 (80.1-98.6)	75.1 (64.6-85.6)	88.3 (79.1-97.4)
	Annual	32	86.9 (81.0-92.8)	75.3 (67.5-83.0)	85.9 (80.1-91.6)
Aspen	Summer	132	82.5 (80.4-84.7)	67.5 (66.0-69.0)	80.0 (78.1-81.8)
	Winter	107	111.0 (109.3-112.8)	64.5 (63.1-65.8)	102.9 (101.4-104.5)
	Annual	239	95.3 (93.0-97.6)	66.1 (65.1-67.2)	90.2 (88.3-92.2)
Balsam poplar	Summer	20	129.0 (121.6-136.5)	89.3 (81.5-97.1)	122.3 (116.8-127.9)
	Winter	22	138.8 (132.4-145.2)	81.1 (70.0-92.3)	127.8 (120.7-134.7)
	Annual	42	134.1 (129.2-139.1)	85.0 (78.3-91.8)	125.2 (120.8-129.6)
Balsam fir	Summer	18	154.6 (147.0-162.1)	85.6 (78.9-92.4)	143.9 (136.6-151.2)
	Winter	38	156.8 (150.3-163.4)	89.8 (85.7-94.0)	146.8 (140.9-152.7)
	Annual	56	156.1 (151.2-161.0)	88.5 (85.0-92.0)	145.9 (141.4-150.4)

¹ Black spruce was sampled only during January, February, and March.

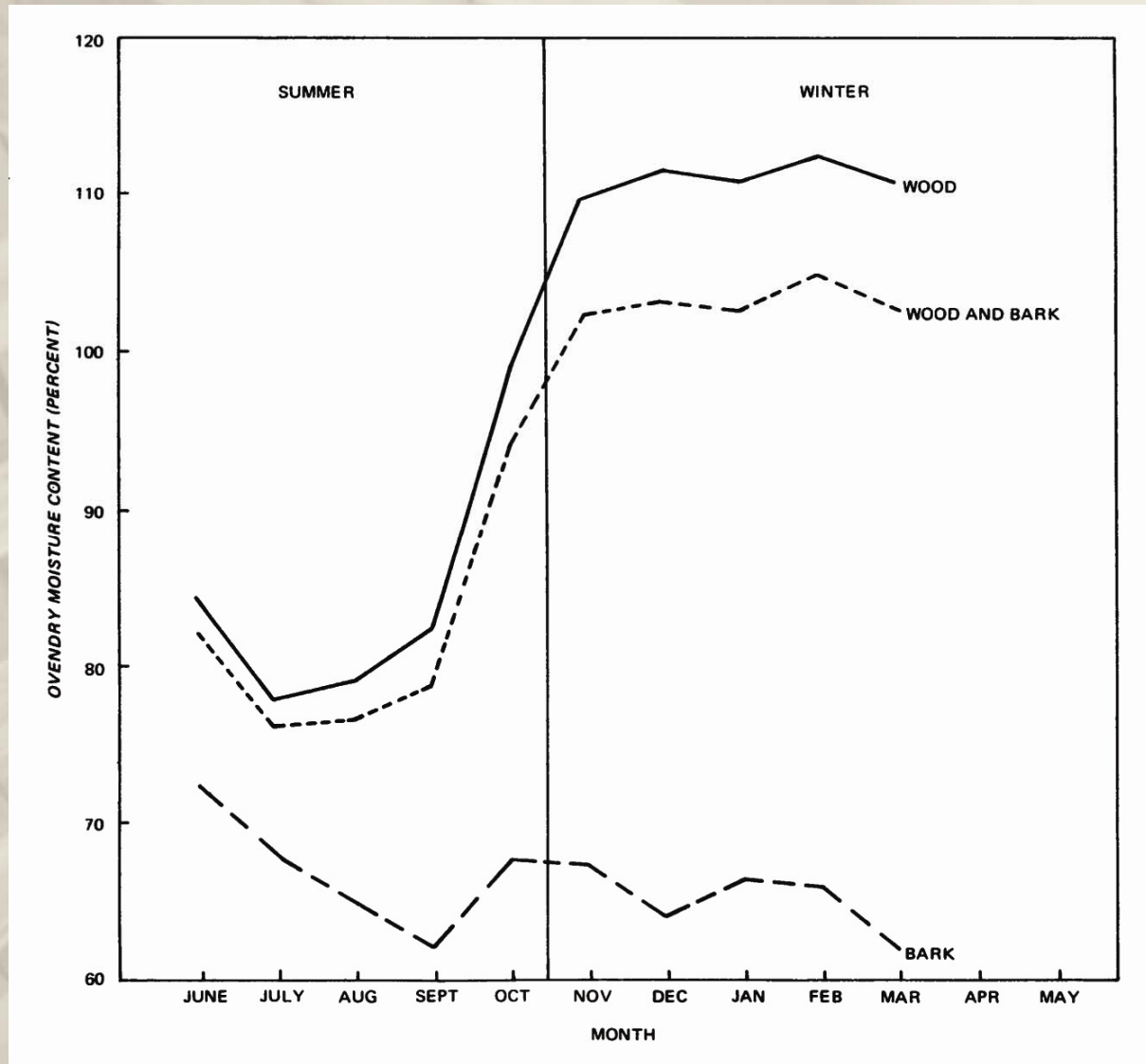
² Calculated at a 95% confidence interval, which indicates that authors can be 95% certain that values within parentheses include the true mean.

Moisture: Aspen by Month

Month	Moisture Content			Basis
	Wood	Bark	Wood and Bark	
	Percent	Percent	Percent	No. of Loads
June	84.2 (80.0-88.4) ¹	72.6 (69.1-76.1)	82.2 (78.4-86.0)	35
July	77.9 (73.8-81.9)	67.9 (64.7-71.1)	76.1 (72.7-79.5)	32
August	78.8 (74.7-82.8)	64.9 (62.5-67.3)	76.5 (73.0-80.0)	30
Sept.	82.2 (77.7-86.7)	62.0 (59.5-64.5)	78.7 (74.8-82.6)	22
Oct.	98.8 (93.5-104.1)	67.7 (64.1-71.3)	93.6 (88.6-98.7)	13
Summer	82.5 (80.4-84.7)	67.5 (66.0-69.0)	80.0 (78.1-81.8)	132
Nov.	109.7 (101.8-117.7)	67.2 (64.4-70.0)	102.5 (95.6-109.4)	9
Dec.	111.4 (107.6-115.2)	63.9 (61.3-66.4)	103.0 (99.7-106.3)	22
Jan.	110.6 (106.5-114.7)	66.3 (62.2-70.4)	102.4 (98.8-105.9)	25
Feb.	112.2 (108.1-116.4)	65.9 (62.9-68.9)	104.6 (100.6-108.6)	19
March	110.7 (107.2-114.2)	61.8 (59.9-63.7)	102.5 (99.5-105.4)	32
Winter	111.0 (109.2-112.8)	64.5 (63.1-65.8)	102.9 (101.4-104.5)	107

¹Calculated at a 95 percent confidence interval, which indicates that authors can be 95 percent certain that values within the parentheses include the true mean.

Moisture: Aspen by Month



Moisture in Heartwood vs. Sapwood

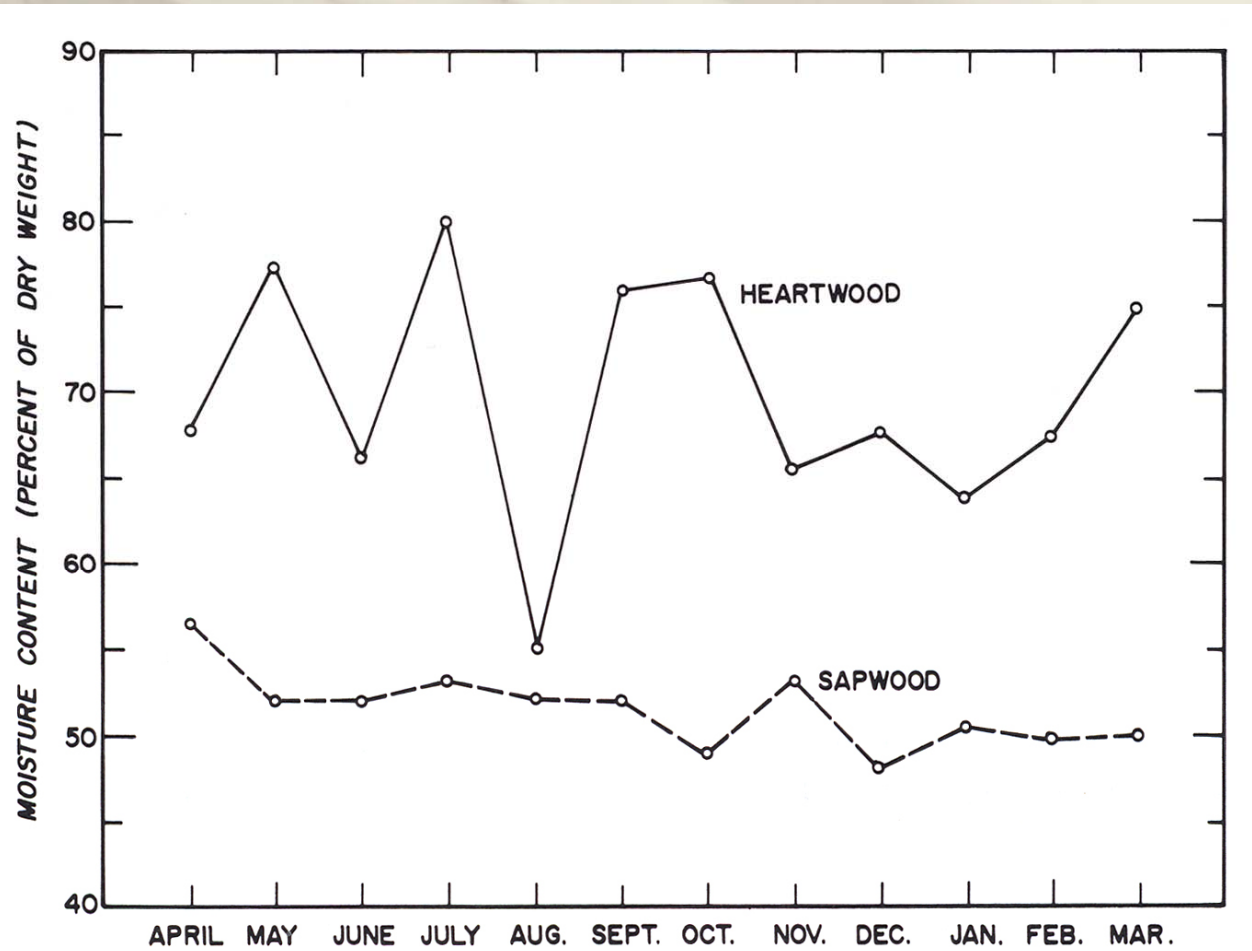


Figure 8-2.—Moisture content in stemwood of hickory related to season of the year.

Moisture in Heartwood vs. Sapwood

Table 3-3. Average moisture content of green wood, by species

Species	Moisture content ^a (%)		Species	Moisture content ^a (%)	
	Heartwood	Sapwood		Heartwood	Sapwood
Hardwoods			Softwoods		
Alder, red	—	97	Baldcypress	121	171
Apple	81	74	Cedar, eastern red	33	—
Ash, black	95	—	Cedar, incense	40	213
Ash, green	—	58	Cedar, Port-Orford	50	98
Ash, white	46	44	Cedar, western red	58	249
Aspen	95	113	Cedar, yellow	32	166
Basswood, American	81	133	Douglas-fir, coast type	37	115
Beech, American	55	72	Fir, balsam	88	173
Birch, paper	89	72	Fir, grand	91	136
Birch, sweet	75	70	Fir, noble	34	115
Birch, yellow	74	72	Fir, Pacific silver	55	164
Cherry, black	58	—	Fir, white	98	160
Chestnut, American	120	—	Hemlock, eastern	97	119

What does all of this mean?

- Wood is variable
- Moisture content varies:
 - within a tree (stem, branches, height)
 - between trees of the same species
 - by age of the tree
 - between different species
 - by location and growing site
 - by weather conditions

What does this mean in Northeastern WI?

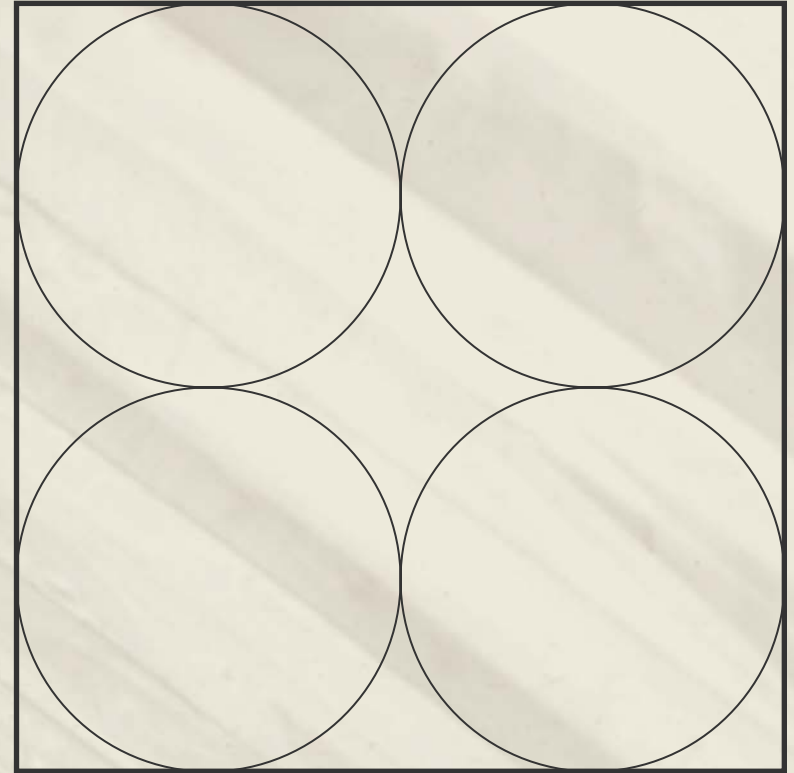
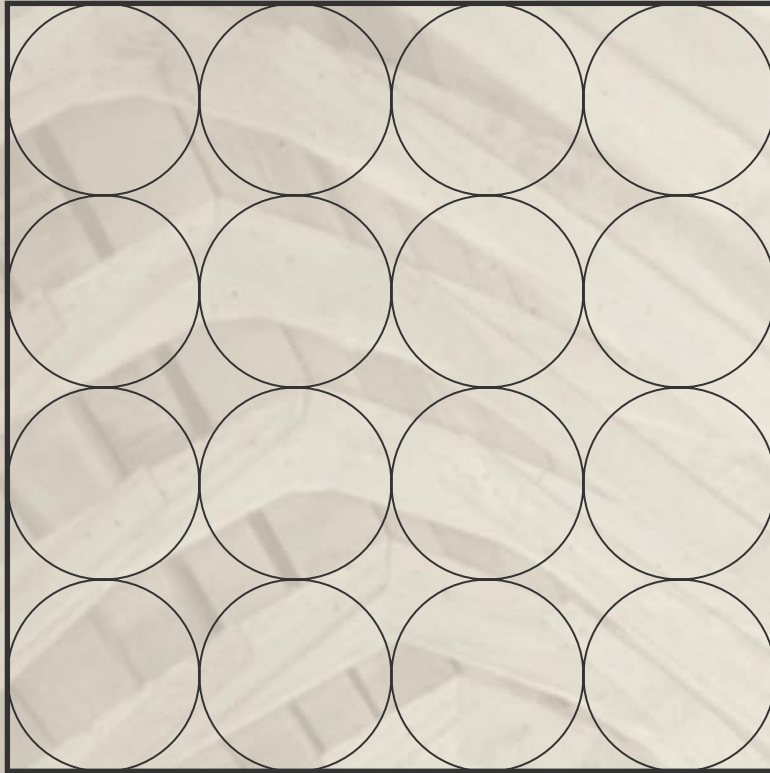
■ Rules of Thumb:

- Average wood moisture content is higher in the winter than the summer
- Average wood moisture content is higher in the winter than in the spring and fall
- Average wood moisture content is lower in the summer than in the spring and fall

Terry's Slide: Weight Scaling

Diameter	Pieces per cord	Cubic feet	Green Weight
4	110	78	3997
5	74	80	4099
6	53	82	4202
7	40	85	4356
8	30	88	4509
9	24	90	4612
10	20	91	4663
11	18	92	4714
12	15	93	4766

Air vs. Wood



- Which one has more wood than air?

What does this mean in Northeastern WI?

■ Rules of Thumb:

- A year-round 4500 weight cord slightly favors the mill in summer, and slightly favors the logger/landowner in winter

Rules of Thumb



Seasonal Examples

- These are examples for aspen pulpwood, assumes woods run to typical pulpwood utilization with larger quality bolts (e.g. good sawbolts) out, as is typical
- Analysis starts with reasonable assumptions for stick scaled cords, in all respects, including MCs for season – the next step is same assumptions with a 4500 lb weight cord

Summary

- Wood Structure and Weight
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Questions

Contact Information

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