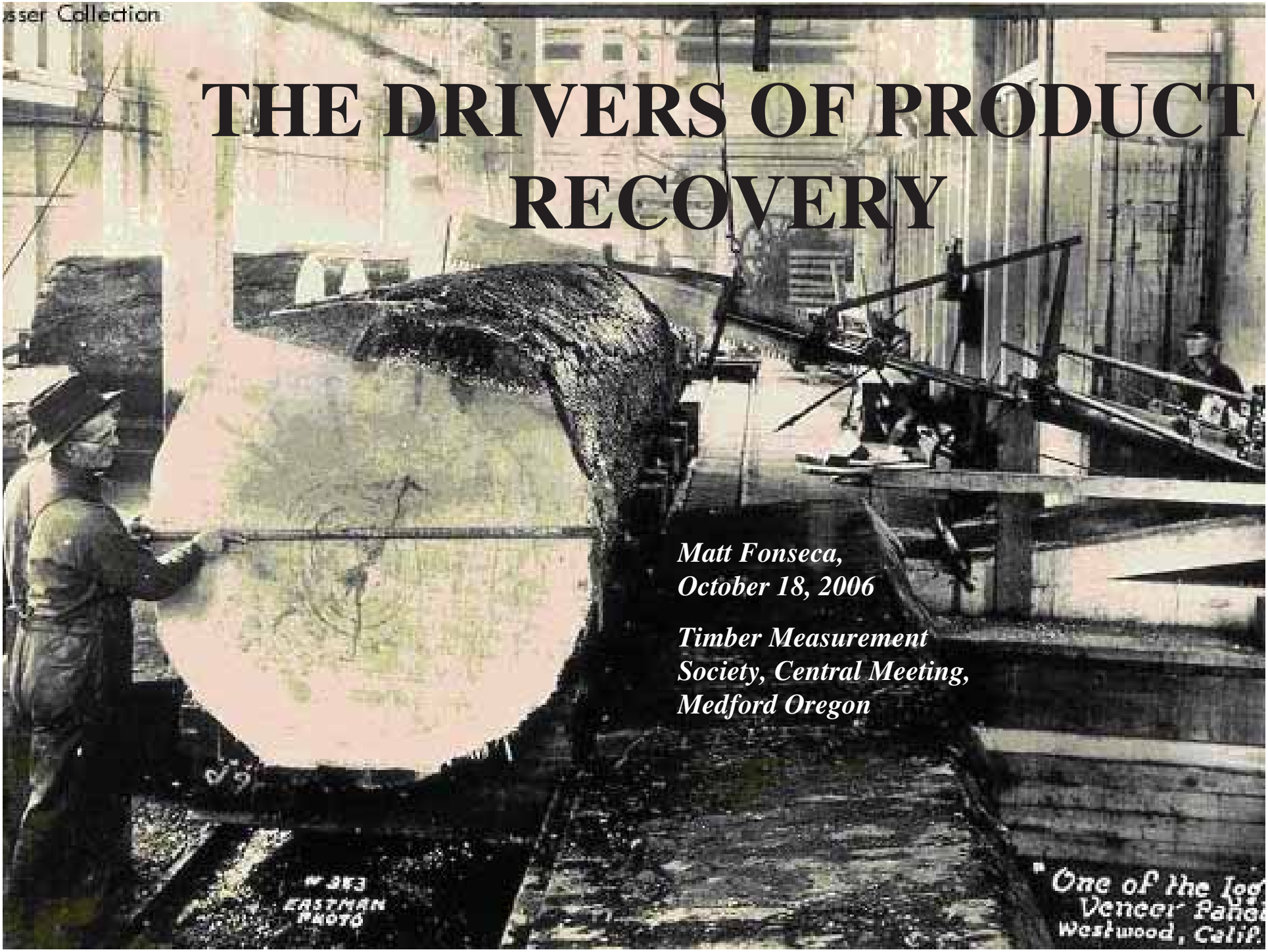


THE DRIVERS OF PRODUCT RECOVERY

Matt Fonseca,
October 18, 2006

Timber Measurement Society, Central Meeting, Medford Oregon

Topics Covered

- Method of log measure
- Lumber recovery
- Plywood and veneer recovery
- Wood chips and other residue

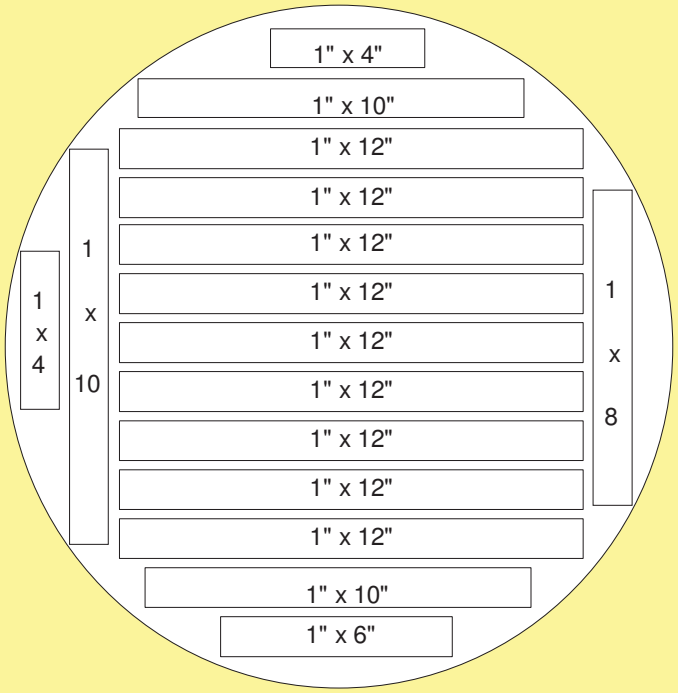
Method of log measure

- Scribner (short-log, long-log)
- Cubic (BC, USFS, Alberta, NWLAG)
- Weight

Scribner

- **Diagram rule (no formula)**

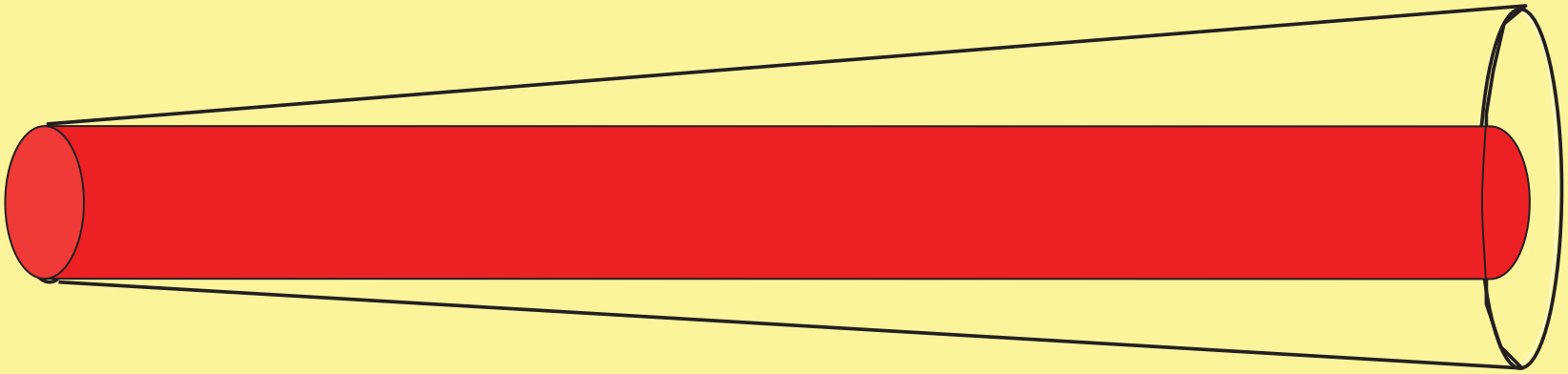
Scribner Decimal C, Diagram Rule



Number of boards	*Board size inches*	*Board feet per lineal foot of log*
9	*1 x 12*	*9.000*
3	*1 x 10*	*2.500*
1	*1 x 8*	*0.667*
1	*1 x 6*	*0.500*
2	*1 x 4*	*0.667*
	Total bf per lineal foot of log =	*13.333*

*13.333 x 16' = 213 bf (rounds to **210 board feet**)*

Scribner scaling cylinder

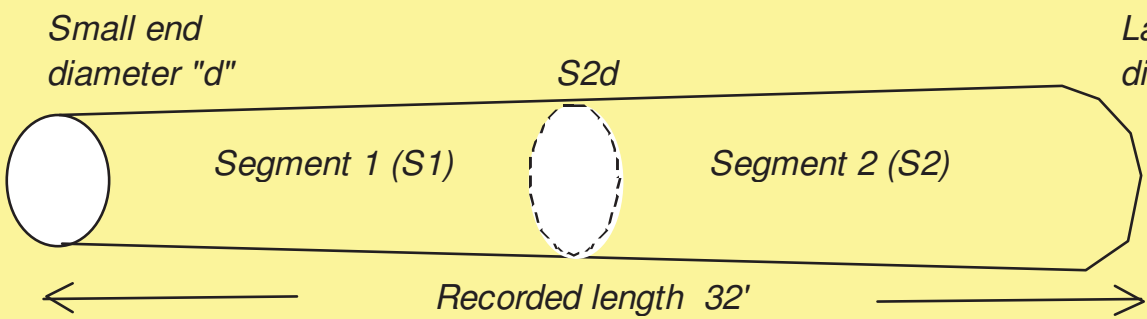


Maximum scaling cylinder is:

- **20’ east of the Cascades and in California**
- **40’ west of the Cascades and in Alaska**

Scribner log volume determination

Two segment log



d = 15" (14.8")

D = 18"

S2d is interpolated as 17"

Segment 1: 16' long, 15"s.e.d. = 14 decimal C or ***140 bf***

Segment 2: 16' long, 17"s.e.d. = 18 decimal C or ***180 bf***

Short log Scribner: total volume = ***320 BF***

Long log Scribner: 32' long 14" s.e.d. = ***230 BF***

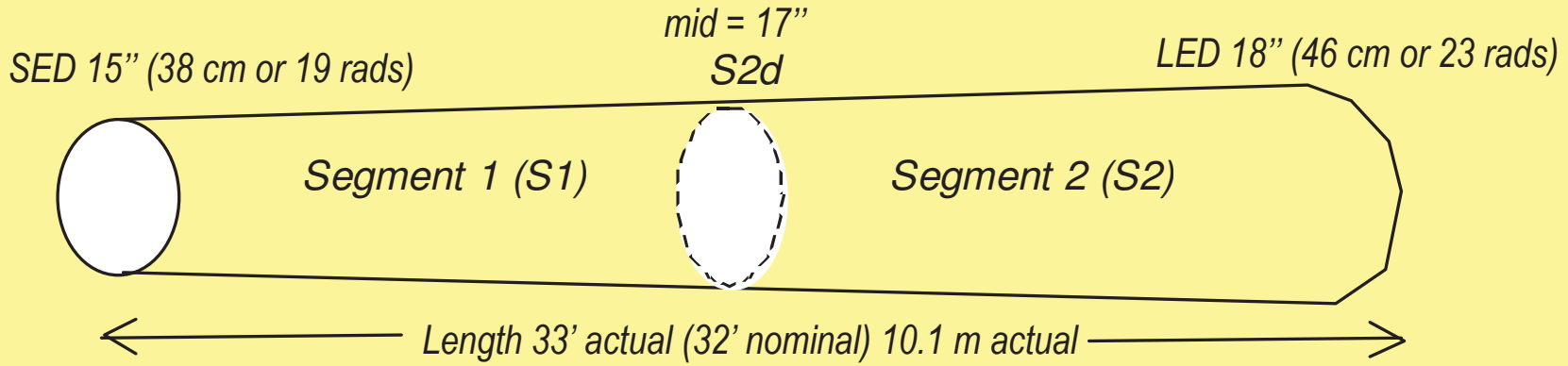
Scribner short log volume chart (Revised)

Small-end diameter	Length of log segment in feet																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
4	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1
5	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
6	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
7	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2	3	3	3	3	3
8	0	0	0	1	1	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3
9	0	0	1	1	1	1	2	2	2	3	3	3	3	3	3	4	4	4	4	4
10	0	1	1	1	1	2	2	3	3	3	3	3	4	4	5	6	6	6	6	7
11	0	1	1	1	2	2	2	3	3	4	4	4	5	5	6	7	7	8	8	8
12	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	10	10
13	1	1	2	2	3	4	4	5	5	6	7	7	8	8	9	10	10	11	12	12
14	1	1	2	3	4	4	5	6	6	7	8	9	9	10	11	11	12	13	14	14
15	1	2	3	4	4	5	6	7	8	9	10	11	12	12	13	14	15	16	17	18
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
17	1	2	3	5	6	7	8	9	10	12	13	14	15	16	17	18	20	21	22	23
18	1	3	4	5	7	8	9	11	12	13	15	16	17	19	20	21	23	24	26	27
19	1	3	4	6	8	9	10	12	13	15	16	18	19	21	22	24	25	27	28	30
20	2	3	5	7	9	11	12	14	16	17	19	21	23	24	26	28	30	31	33	35

Scribner long-log volume chart

Small-end dia. log segment in inches	Length of log segment in feet																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
4	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3
5	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4
6	3	3	3	3	3	3	3	3	4	4	4	5	5	5	5	6	6	6	6	6
7	3	4	4	4	4	4	4	5	5	5	5	6	6	6	6	6	7	7	7	7
8	4	4	4	4	5	5	5	5	5	6	6	7	7	7	8	8	8	8	9	9
9	5	5	6	6	6	6	7	7	7	7	7	9	10	10	10	10	11	11	11	12
10	7	8	8	9	9	9	10	10	10	11	11	12	13	13	13	14	14	14	15	15
11	9	9	10	10	10	11	11	12	12	13	13	14	15	15	16	16	17	17	18	18
12	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20
13	13	13	14	15	15	16	16	17	18	18	19	19	20	21	21	22	22	23	24	24
14	15	16	16	17	18	19	19	20	21	21	22	23	24	24	25	26	26	27	28	29
15	19	20	20	21	22	23	24	25	26	27	28	28	29	30	31	32	33	34	35	36
16	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
17	24	25	27	28	29	30	31	32	33	35	36	37	38	39	40	42	43	44	45	46
18	28	29	31	32	33	35	36	37	39	40	41	43	44	45	47	48	49	51	52	53
19	31	33	34	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58	60
20	37	38	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66	68	70

Cubic log volume determination



US Cubic Log scale

*Segment 1 calculation: $(15^2 + 17^2) \times 16 \times .002727 =$ **22.4 ft³** (0.634 m³)*

*Segment 2 calculation: $(17^2 + 18^2) \times 16 \times .002727 =$ **26.7 ft³** (0.756 m³)*

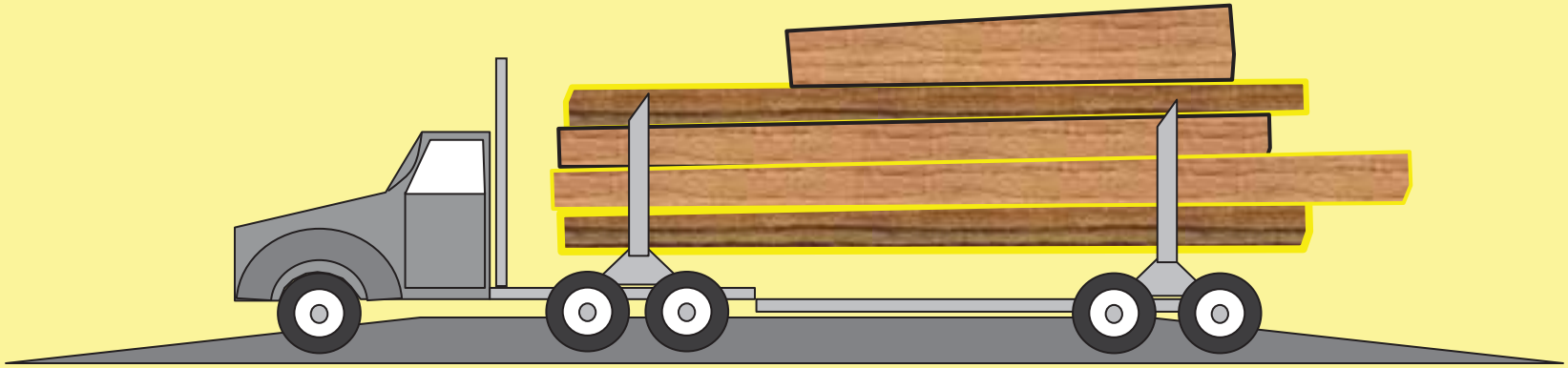
*Total log volume = **49.1** ft³ (1.390 m³)*

BC Cubic Log scale

*Log volume: $(19^2 + 23^2) \times 10.1 \times .00015708 =$ **1.412 m³** (49.9 ft³)*

Weight scale (Ton)

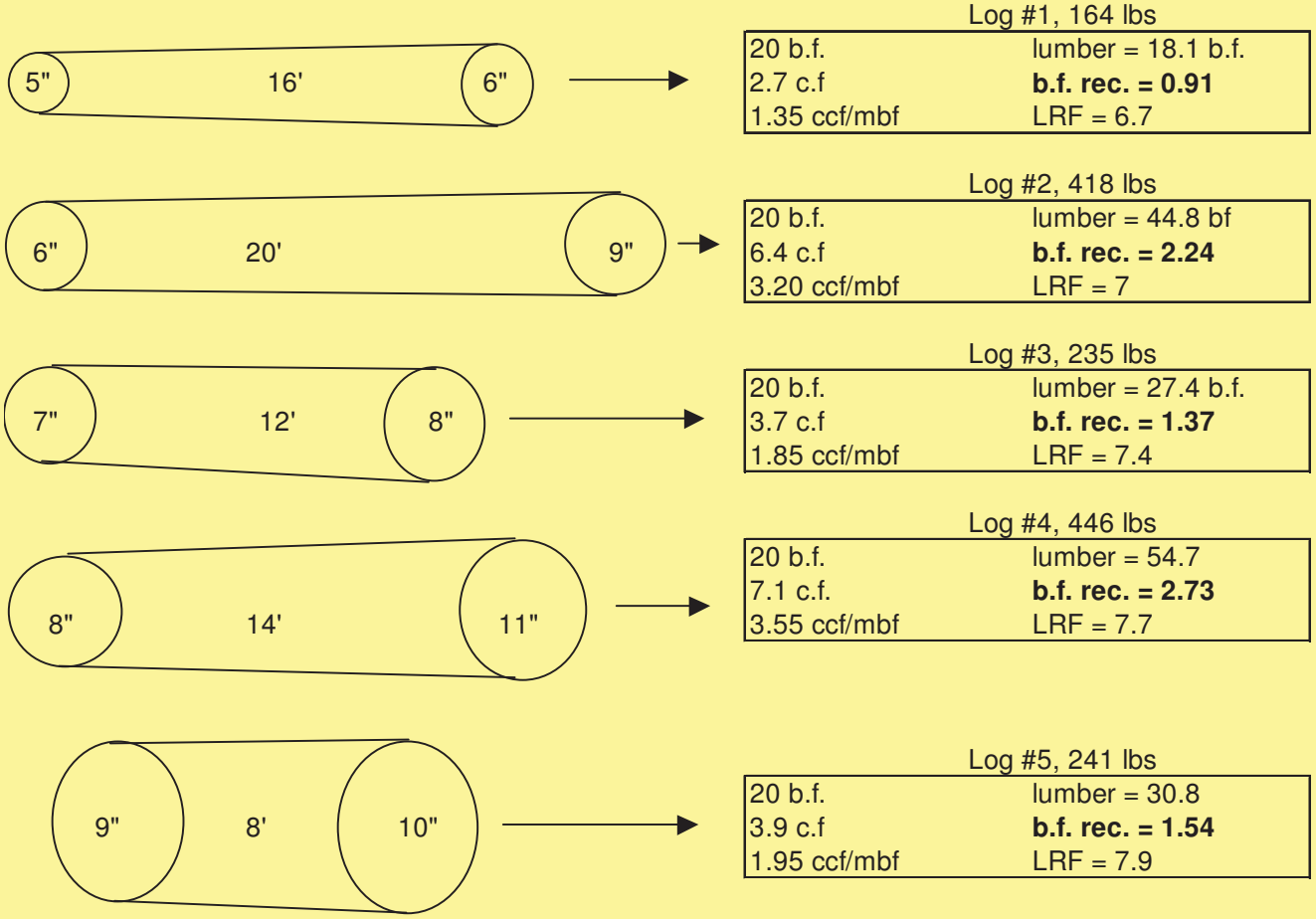
- Normally converted to volume via a ratio



56,200 lbs of logs ÷ 60.7 lbs ft^3 = 925.9 ft^3

25,488 kg of logs ÷ 972 kg m^3 = 26.22 m^3

Comparing log scales



Drivers of lumber recovery

Typical distribution of fiber in the lumber manufacturing process

	Lumber	Chips	Sawdust	Shavings	Shrinkage
Boards	41%	31%	12%	13%	3%
Stud	48%	34%	7%	8%	3%
Dimension	48%	33%	7%	9%	3%
Hardwood	44%	25%	14%	10%	7%

Note: Based on recoveries on the following average small-end diameter logs 10" - boards, 7" – studs, 10" – dimension, 13" – hardwood.

Lumber recovery measure

- When production is measured in the same units as input, recovery is reflected as % (1 mbf log; 1.5 mbf lumber = 150%; 100 ft^3 log; 52 ft^3 lumber = 52%
- When production is measured in board foot and logs measured in cubic, recovery is measured via "lumber recovery factor" (LRF) (100 ft^3 (2.832 m^3) log; 780 bf of lumber = LRF of 7.8 (275 metric LRF)

Factors affecting lumber recovery; milling efficiency

- Saw kerf can range from 0.09-0.32 ″ and take 7-14% of log volume
- Target size needs to be large enough to account for shrinkage, planing allowance (for the type of lumber being made), and allow for size variation
- Different lumber products require different amounts of fiber due to bf measure, wane allowance and finish requirements

Factors affecting lumber recovery; milling efficiency (cont.)

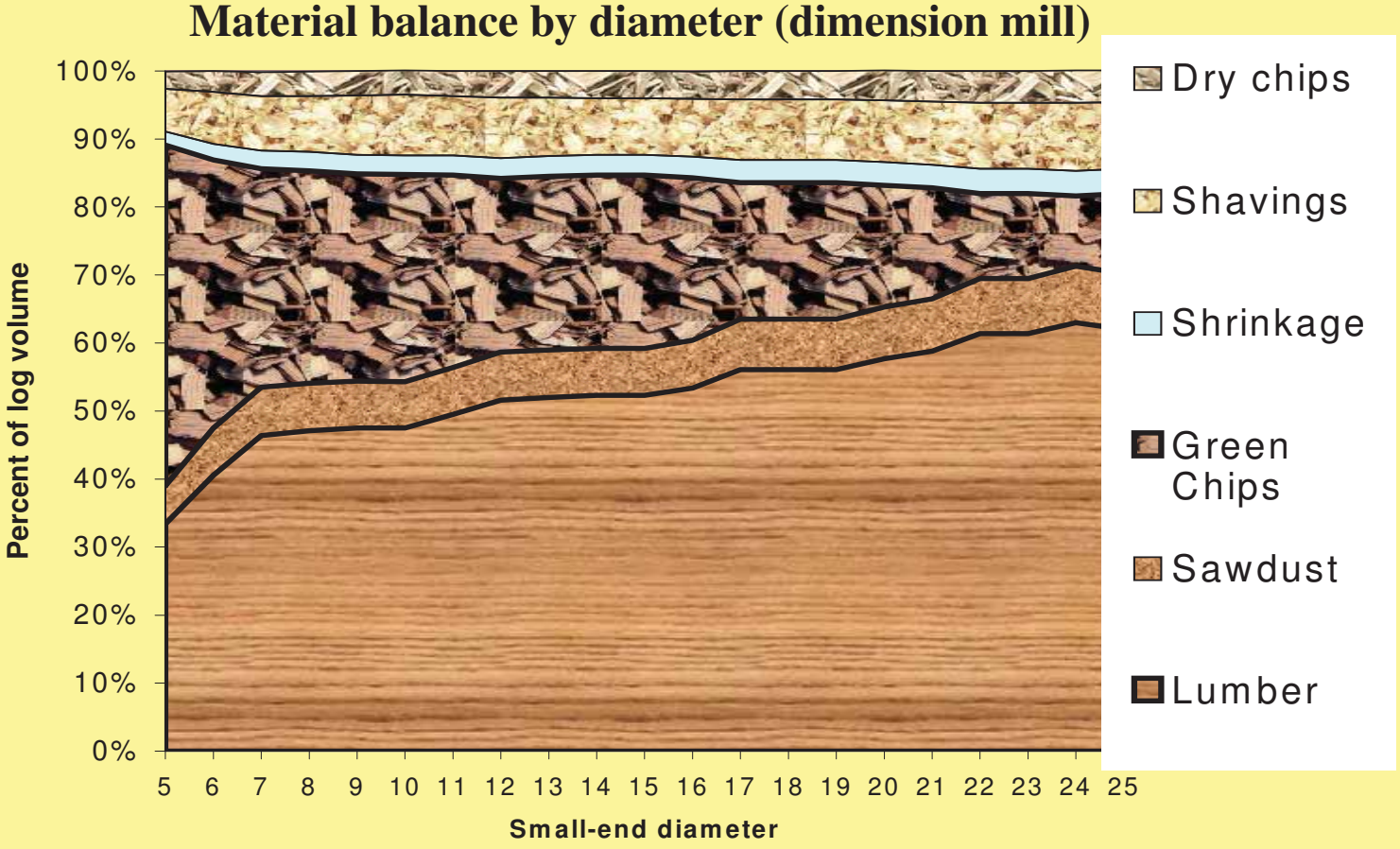
- Optimization equipment: finds the optimal ways of bucking log stems into sawmill lengths and cutting lumber of a particular size and orientation given the shape of a log (including curve sawing). This technology can greatly improve lumber recovery

Factors affecting lumber recovery; log characteristics

- Diameter - cubic log scale: for cubicly scaled logs, recovery increases as diameters increase owing to the effects of slab loss, taper, and lumber size requirements

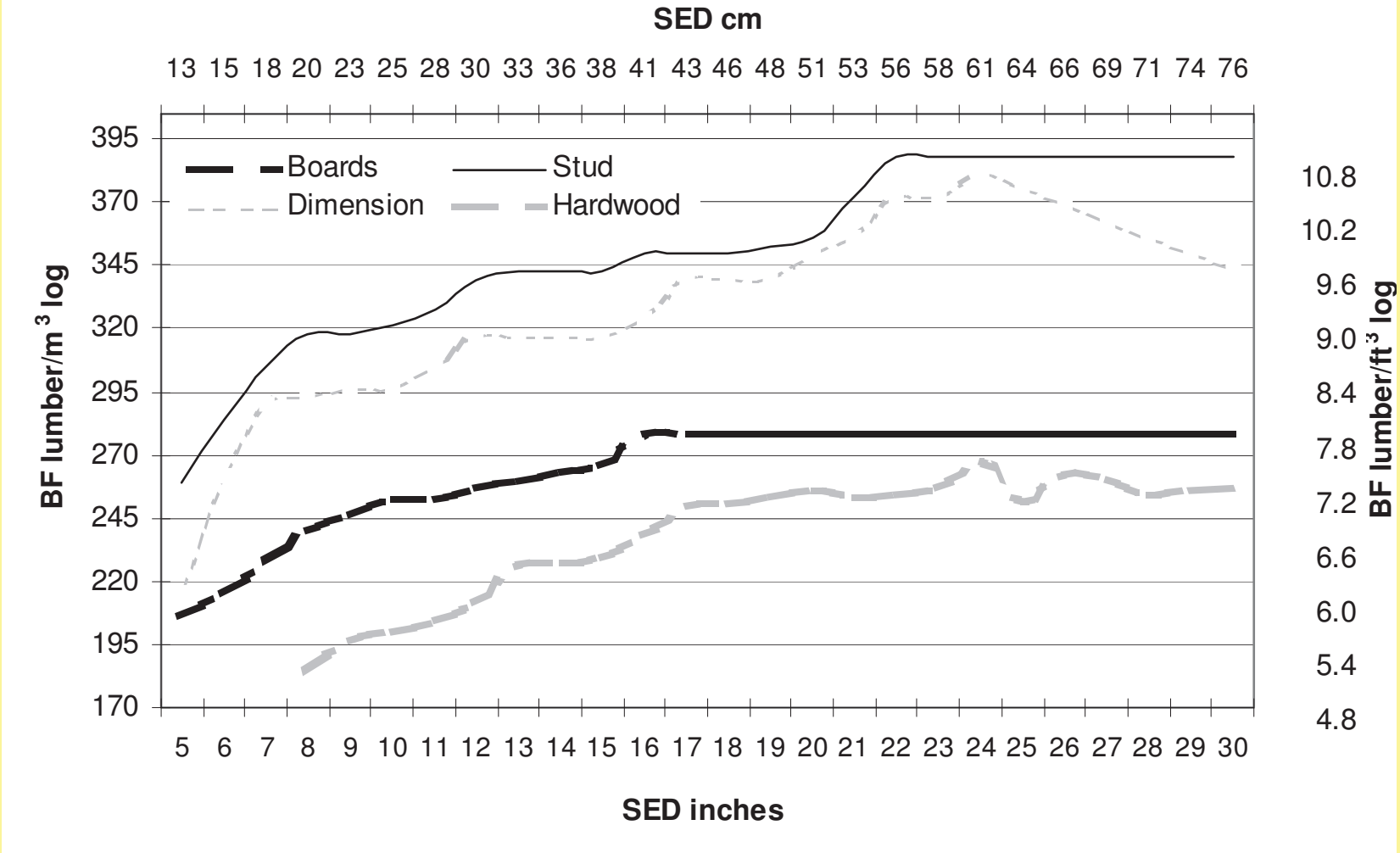
- Diameter - bf scale: recovery is erratic in the smaller diameters, but has a general downward trend as diameter increases

Recovery trends by log size and lumber products made

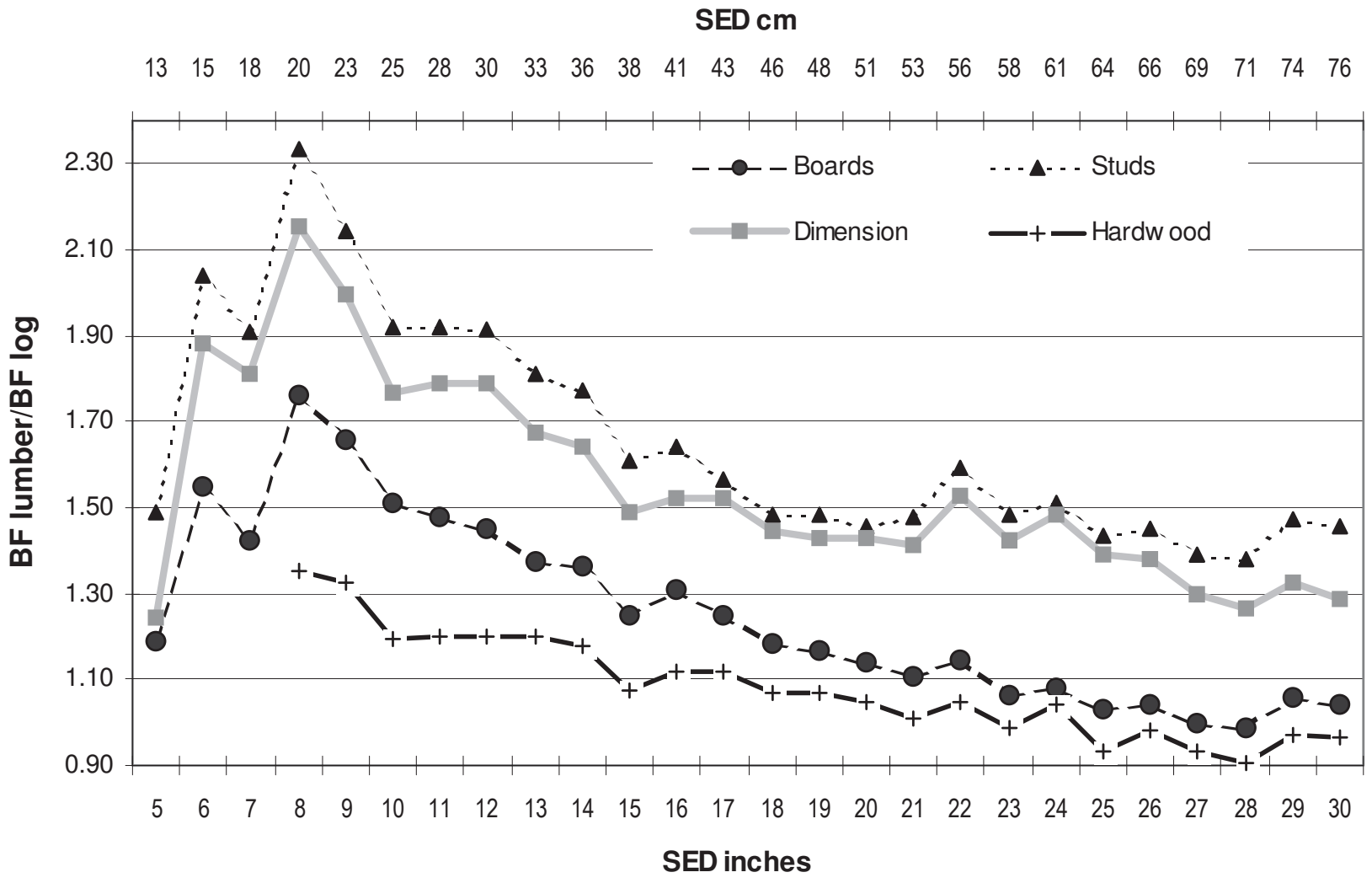


Lumber recovery by small-end diameter of log and mill type, actual log volume (B.C. Firmwood)

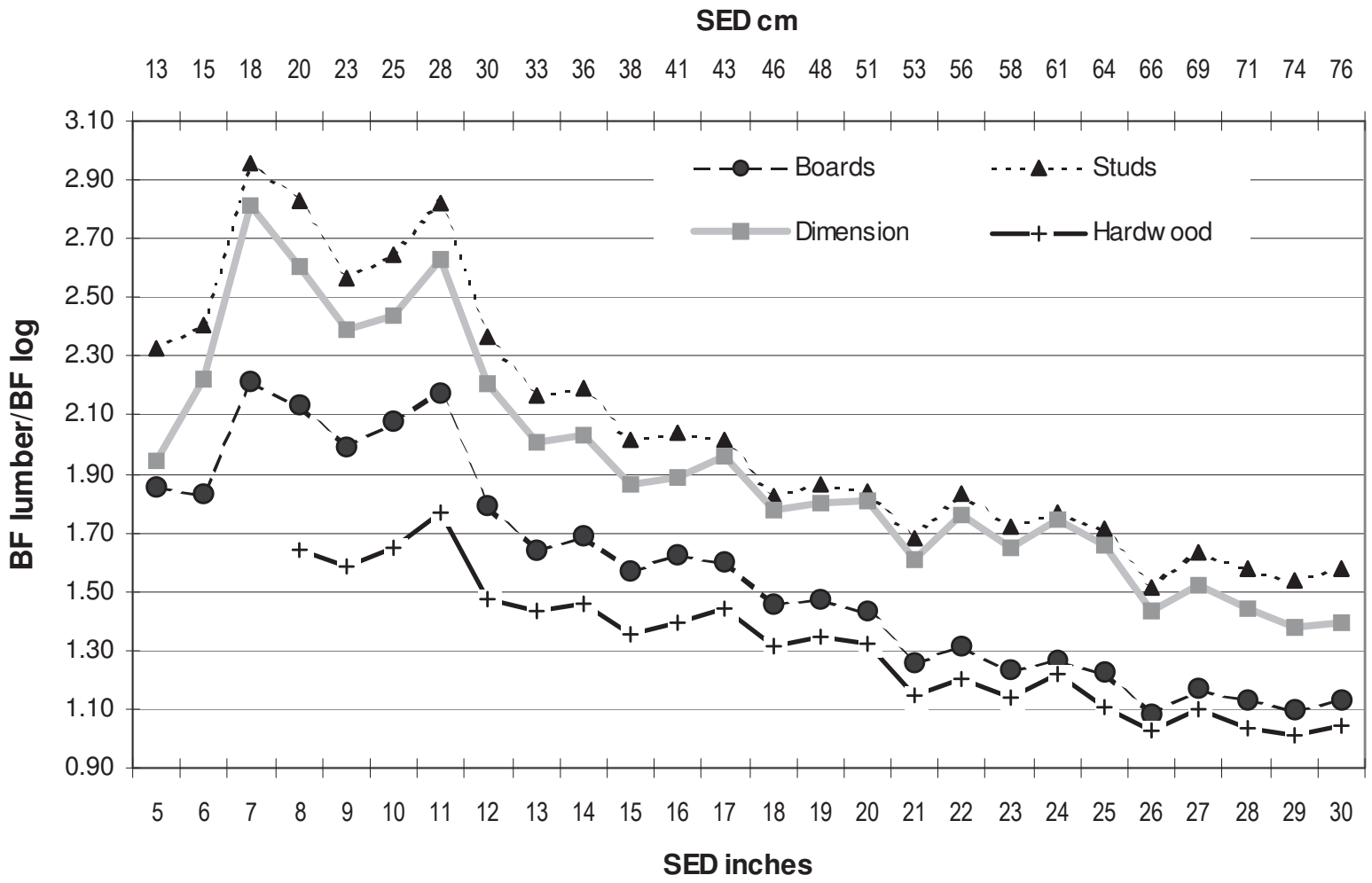
(LRF)



Scribner Short Log Rule recovery by lumber product and log diameter



Scribner Long Log Rule recovery by lumber product and log diameter



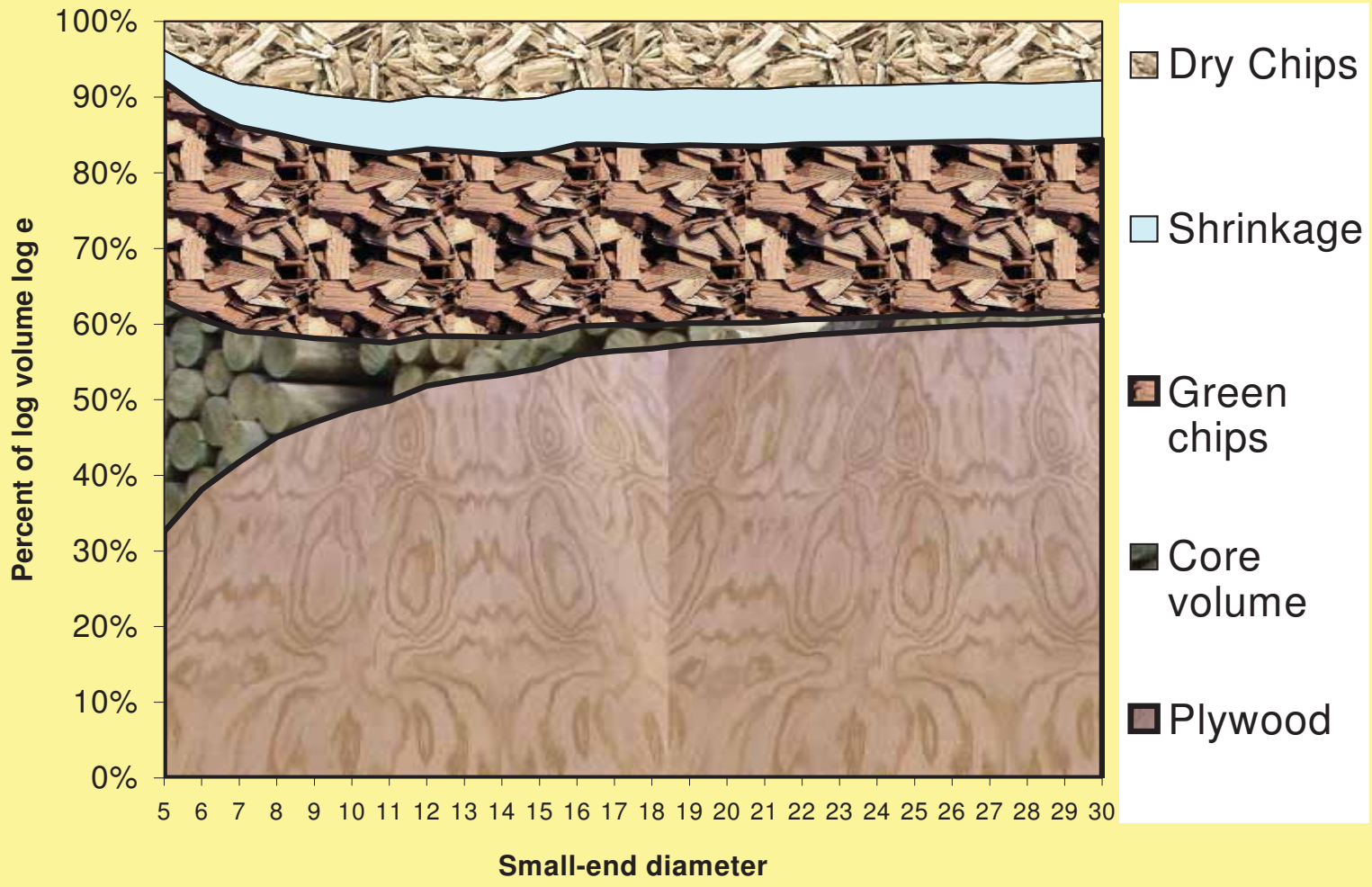
Plywood/veneer recovery measure

- When log volume is measured in BF and production is measured in ft^2 3/8", recovery is reflected as ft^2 3/8" per bf log scale, e.g., if 3,100 ft^2 3/8" of plywood is made per mbf log, recovery is 3.1
- When logs are measured in cubic, recovery is measured in ft^2 3/8" per ft^3 log, e.g., if 18 ft^2 3/8" is produced per ft^3 log, VRF is 18 (note as there is 32 ft^2 3/8" in a ft^3, 18 ÷ 32 = 56.25% recovery

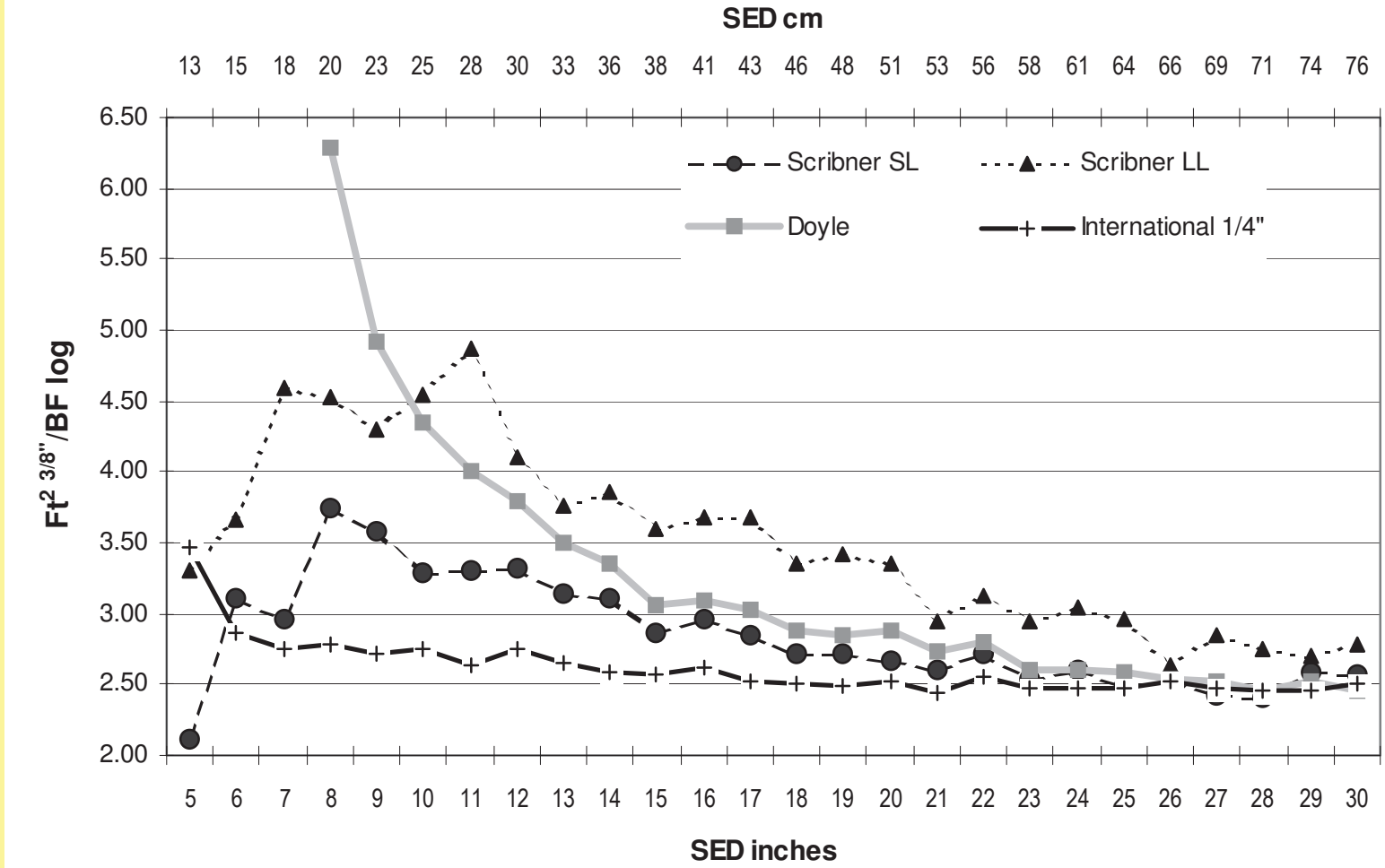
Factors affecting ply/veneer recovery; milling efficiency

- Clipping: Correct optical reading and calibration of cuts is tantamount to obtaining good recovery
- Centering on lath via the charger
- Diameter: Recovery trends upward steeply as diameters increase, as a result of a constant core size (2.5 – 3.5″) and because loss from round-up is much higher in small logs than for large logs

Plywood recovery by small-end diameter



Plywood recovery by small-end diameter, product output scaled logs



Wood chips and other residue recovery

- ✓Chips
- ✓Sawdust
- ✓Shavings
- ✓Bark

	ft^3 residual/mbf lumber				
	Log	Lumber	Chips	Sawdust	Shavings
Boards	139.9	56.6	44.6	16.6	18.3
Stud	115.7	55.6	38.8	8.6	9.5
Dimension	119.3	56.6	40.6	8.1	10.6
Hardwood	155.6	69.2	39	21.6	15.5
	ft^3 residual/msf plywood				
	Log	Plywood	Chips	Core	Dry fiber
Plywood	62.5	31.3	15.6	4.7	7.2

Wood chips and other residue recovery; units of measure

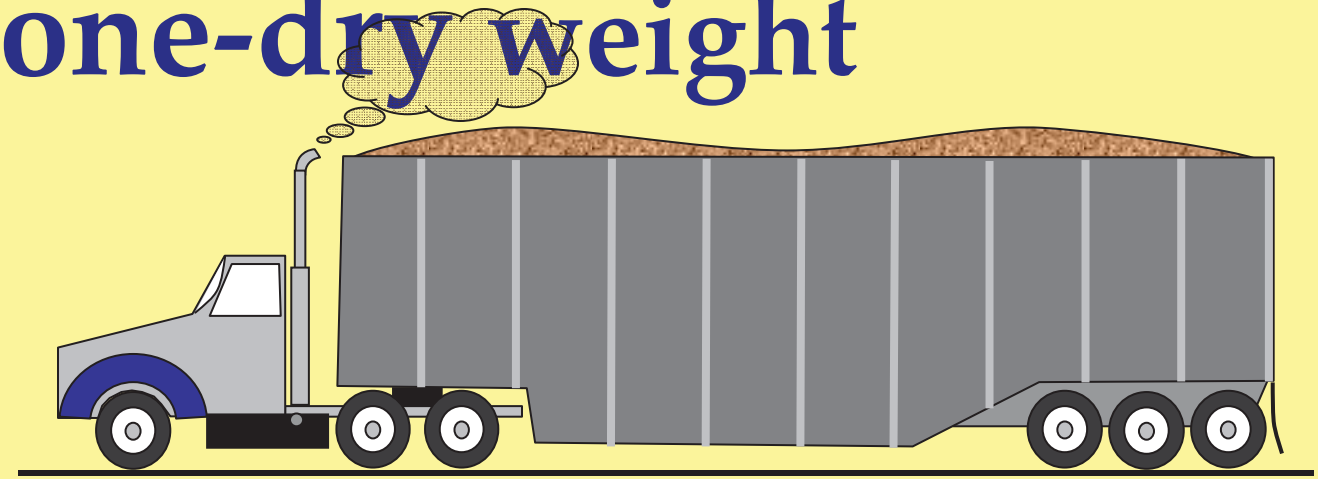
- **Bone-dry weight**
  - **Bone-dry unit (2,400 lbs BD)**
  - **Bone-dry ton (2,000 lbs BD)**
  - **Bone-dry tonne (1,000 kg BD (2,205 lbs))**

Bone-dry weight

- The weight of wood with all of the moisture removed
- Normal procedure is to establish the weight in the green-state; take a representative sample of fiber, weigh it green, dry it in an oven at (+ or –) 217 ° F (103° C) until weight stabilizes; divide bone-dry weight by green weight and multiply ratio times non-sampled population.

Bone-dry weight

Example:



Net weight = 71,000 lbs

Green chip sample = 922 g	**497 ÷ 922 = 53.9% fiber**
Bone-dry sample = 497 g	**.539 x 71,000 = 38,269 lbs**

- **Bone dry Unit: 38,269 ÷ 2,400 = 15.945 BDU**
- **Bone-dry ton: 38,269 ÷ 2,000 = 19.135 BDT**
- **Bone-dry tonne 38,269 ÷ 2,205 = 17.356 BDMT**

Bone-dry weight and volume conversions for selected tree species

Common Name	Latin Name	Green with bark Lbs/ft^3	Specific Gravity (green volume)	BD weight kg/m^3	BD weight lbs/ft^3	ft^3/BDU*	ft^3/BDT*	Ton/BDU**	Tonne/BDU**	Ton/BDT Tonne/BDMT**
North American Conifers										
Grand fir	*Abies grandis*	55.2	0.35	350	21.8	109.9	91.6	3.03	2.75	2.53
Subalpine fir	*Abies lasiocarpa*	47.2	0.31	310	19.3	124.1	103.4	2.93	2.66	2.44
Western larch	*Larix occidentalis*	57.5	0.48	480	30	80.1	66.8	2.3	2.09	1.92
Engelmann spruce	*Picea engelmannii*	57.9	0.33	330	20.6	116.6	97.1	3.37	3.06	2.81
White spruce	*Picea glauca*	49.8	0.33	330	20.6	116.6	97.1	2.9	2.63	2.42
Lodgepole pine	*Pinus contorta*	56.5	0.38	380	23.7	101.2	84.3	2.86	2.59	2.38
Western white pine	*Pinus monticola*	52.6	0.35	350	21.8	109.9	91.6	2.89	2.62	2.41
Ponderosa pine	*Pinus ponderosa*	63.4	0.38	380	23.7	101.2	84.3	3.21	2.91	2.67
Douglas fir	*Pseudotsuga menziesii*	59.4	0.45	450	28.1	85.5	71.2	2.54	2.3	2.11
Western red cedar	*Thuja plicata*	38.8	0.31	310	19.3	124.1	103.4	2.41	2.18	2
Western hemlock	*Tsuga heterophylla*	58.9	0.42	420	26.2	91.6	76.3	2.7	2.44	2.25
Mountain hemlock	*Tsuga mertensiana*	67	0.42	420	26.2	91.6	76.3	3.07	2.78	2.56

Residual product recovery

Chips:

- If chipping equipment is set up properly, sound green wood fiber should yield less than 5% fines, leaving 95% available chips (dry or unsound wood may yield less)
- Recovery of BD chips will be relative to specific gravity, i.e., wood with an SG of .48 will yield 50% more than wood with an SG of .32
- Less residual chips are produced as log diameter increases

Whole log chips recovery

Example:

Estimated green tons and ft^3/BDU for thinning whips that will be about 10% larch, 30% DF, 50% GF, and 10% LPP (using table from slide 29):

Tons =: (0.1 x 2.3) + (0.3 x 2.54) + (0.5 x 3.03) + (0.1 x 2.86) = 2.79 tons/BDU

Ft^3 =: (0.1 x 80.1) + (0.3 x 85.5) + (0.5 x 109.9) + (0.1 x 101.2) = 98.73 ft^3/BDU

Residual chip recovery

Example:

Approximate BDU chips per mbf lumber at a stud mill:

- **DF: 38.8 ft^3 chips ÷ 85.5 ft^3 per BDU= 0.454 BDU/MBF lumber**
- **AF: 38.8 ft^3 chips ÷ 124.1 ft^3 per BDU = 0.313 BDU/MBF lumber**

	ft^3 residual/mbf lumber				
	Log	Lumber	Chips	Sawdust	Shavings
Boards	139.9	56.6	44.6	16.6	18.3
Stud	115.7	55.6	38.8	8.6	9.5
Dimension	119.3	56.6	40.6	8.1	10.6
Hardwood	155.6	69.2	39	21.6	15.5

Lumber chip recovery

Example:

#5 larch, 1”x 4”x 8’ = 13.44 bf per ft^3 rough green

Target size is: 0.94” x 3.80” x 8’

- **1000 ÷ 13.44 = 74.4 ft^3 of lumber per MBF**
- **74.4 ÷ 80.1 ft^3 per BDU = 0.93 BDU/MBF**
- **0.93 x $80/BDU = $74.40/MBF as chips**

Sawdust recovery

- Generally higher in board mills than in stud or dimension mills (more kerfs)
- Highly variable depending on saw-kerf and the use of slabber heads
- Fairly constant by diameter when gauged by lumber production, but increases with diameters when gauged by cubic log volume

Shavings recovery

- Much higher in board mills than in stud or dimension mills (1″ thick vs. 2″ thick)
- If using rough-dry size vs. finished size to calculate BDU of shavings, remember to adjust SG for shrinkage, e.g., if shrinkage = 4.5% of lumber volume and SG is 0.33, adjusted SG is: 0.33 ÷ (1-.045) = 0.346

Bark Recovery

- In general, bark constitutes 10% of the weight and volume of softwoods
- Can vary substantially from one species to another or by variation within a species
- Some variation by size; smaller logs generally have a higher percentage of bark relative to big logs
- If one is trying to estimate available bark yield, be careful not to assume the percentages published (bark falls off in handling)