Assessing Target Moisture Content in the Kiln Drying of Square Hemlock Timbers

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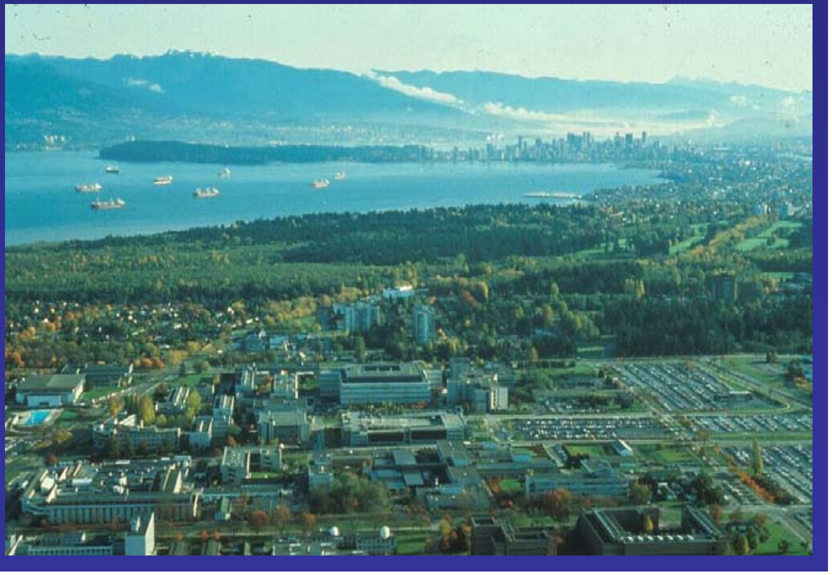
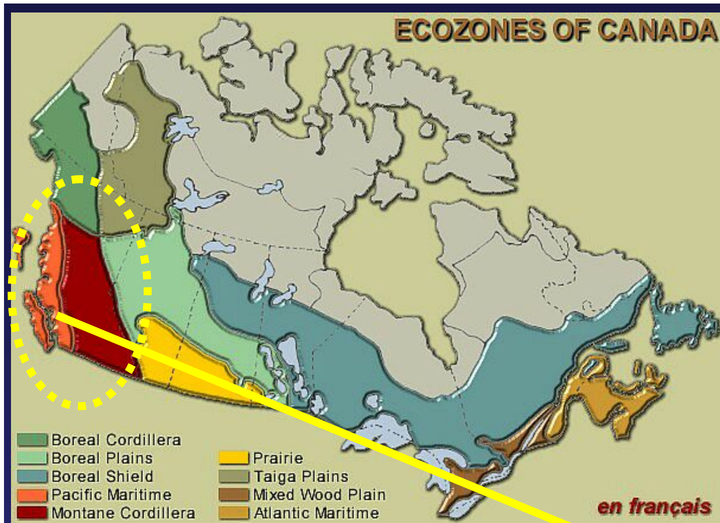
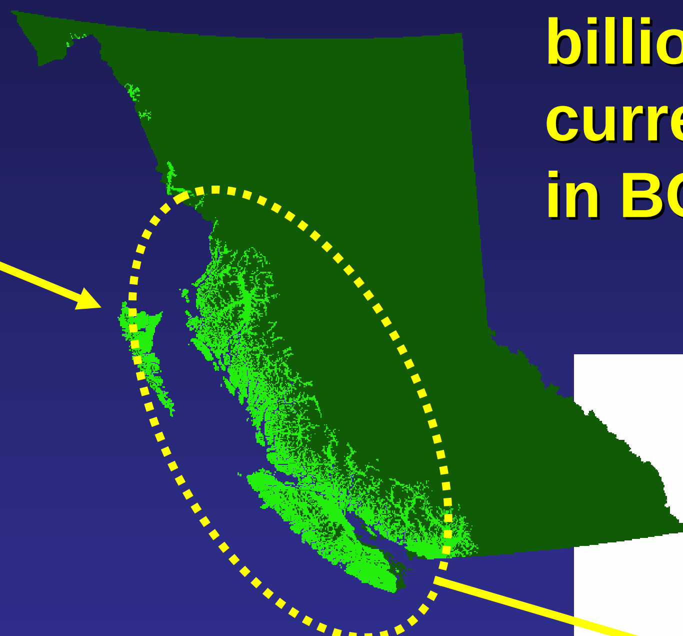


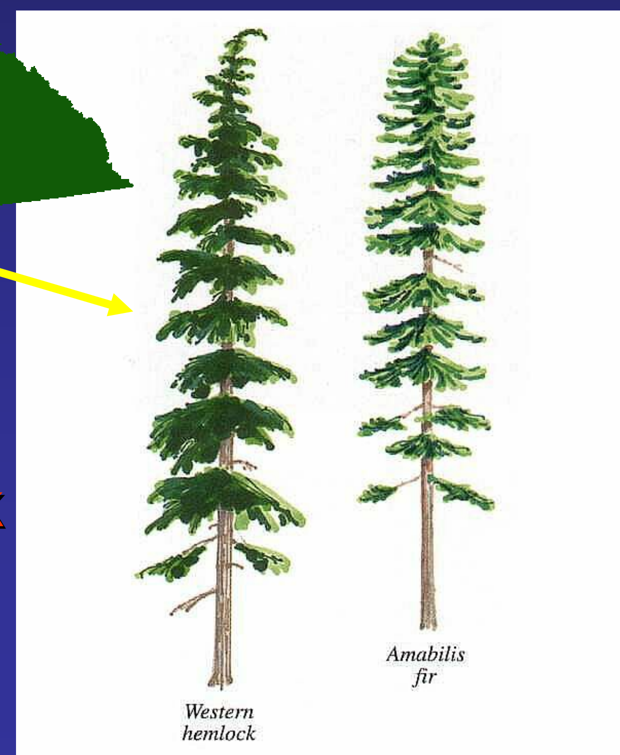
Outline

- What was Dried
- Why it is so Difficult to dry
- Objective of Study
- Methods of Measurements, Drying Runs and Drying Schedule
- Results and Conclusions of Lab Scale Drying and the Industrial Scale Drying
- Summary





about 3 million cubic meters (1.3 billion board feet) currently in stock in BC forests



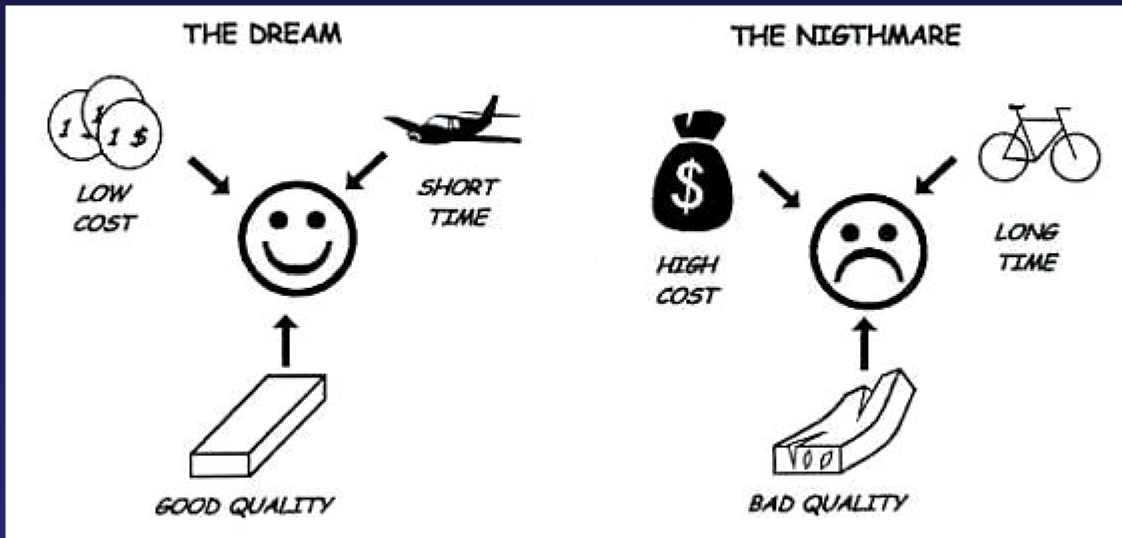
Pacific Coast Hemlock (PCH)

- **25-30% amabilis fir**
- **75-70% western hemlock**

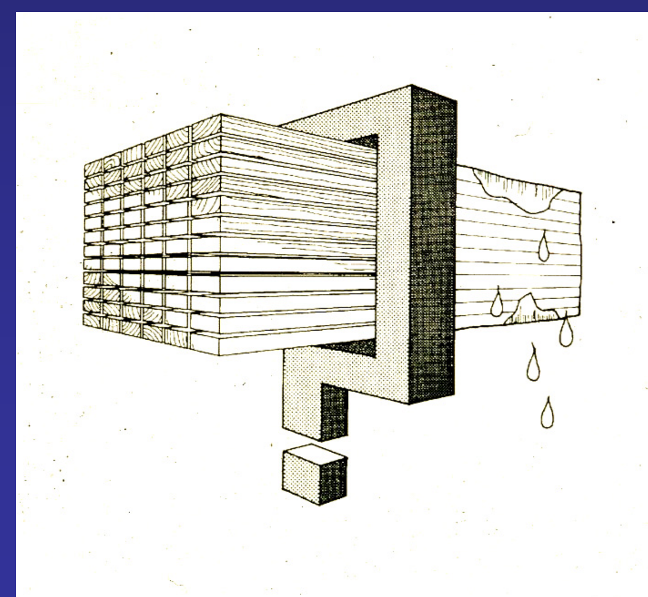
- high quality wood
- uses in Japanese house construction (Zairai)

PCH rainforest

Drying of Lumber



- typical PCH case
- difficult to dry wood
- how can we improve drying yield?



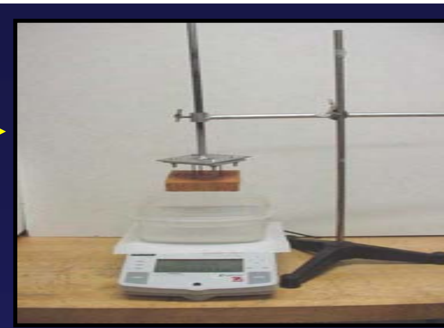
Drying Issues of PCH

1. Differences between hemlock and fir (green Moisture Content, Density)
2. Wet pockets
3. High variability in final Moisture Content
4. Final product stability
5. Discoloration - brown stain

Objective

The objective of this study was to evaluate the moisture content classes, stability, quality and profit generated by kiln drying of PCH square timbers (105mm) to different target moisture contents on two scales: (1) laboratory and (2) industrial.

Timber Evaluations



Density

green & dry Weights

green & dry Dimensions

green & dry Moisture Content

dry shell & core Moisture Content

Timber Evaluations continued

bow

twist

diamonding

shape distortions were measured on all specimens in the lab phase and on a representative sample in the industrial phase

Measuring Table

Phase 1: Drying Schedule

5 Drying Runs using target moisture contents of: 12, 15, 20, 25 and 30%

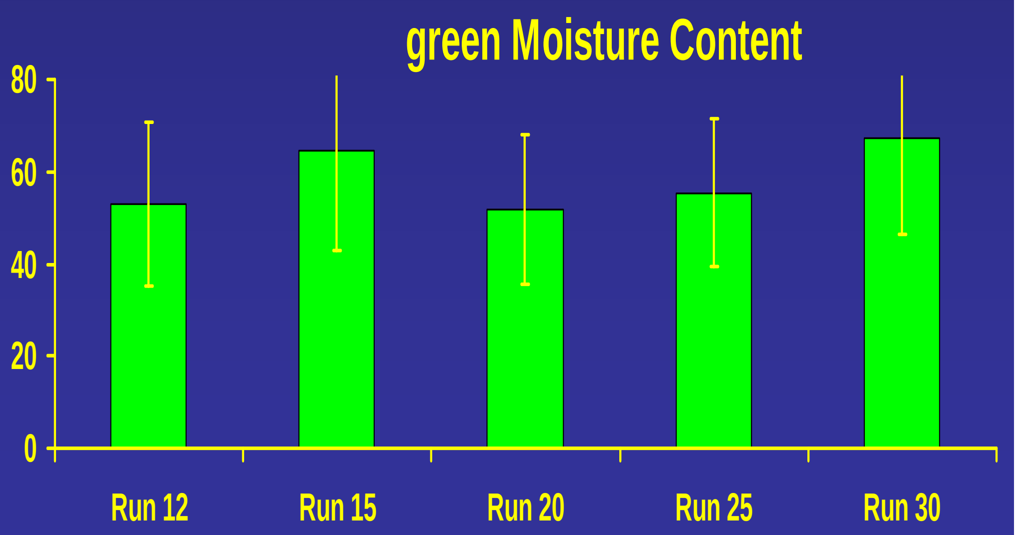
Step	time	T_{db}	T_{wb}	M_{emc}	fan rev
	(hr)	(^oC)	(^oC)	(%)	(hr)
1	6	49	49	25	3
2	24	52	51	21.5	12
3	24	55	53	17.5	12
4	24	58	55	15.6	12
5	24	62	57	12.6	12
6	24	66	59	10.6	12
7	24	70	61	8.6	12
8	24	74	63	7.8	12
9	$M=M_t$	78	65	7	12
10	12	72	69	15.1	6

160 specimens of 115x115x2400 mm (4-1/4” x 4-1/4” x 8’) in each run

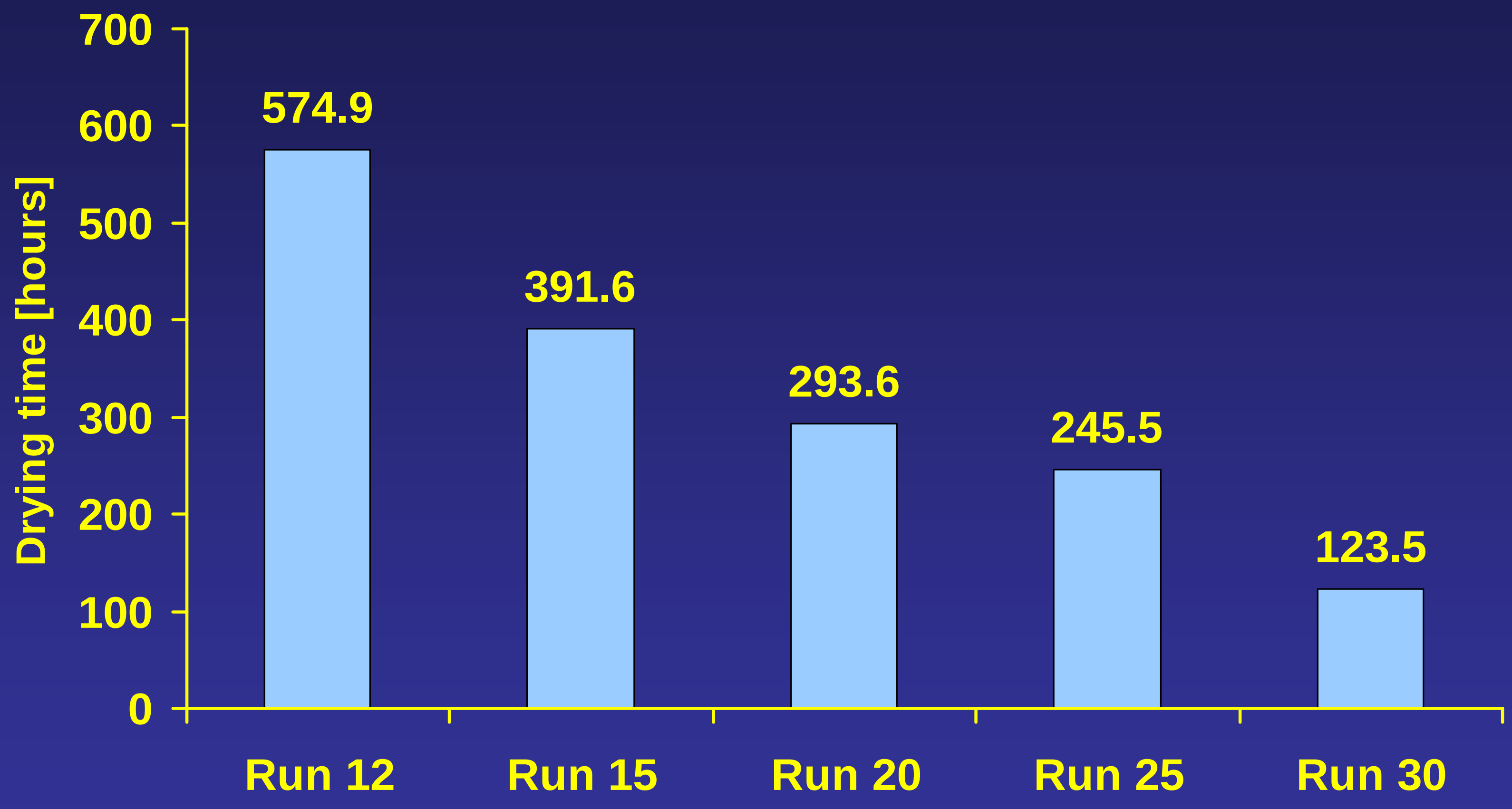
Phase 1: Density and green Moisture Content

DENSITY	Run 12	Run 15	Run 20	Run 25	Run 30
Mean (g/cm^3)	0.41	0.38	0.41	0.41	0.39
St. dev.	0.05	0.04	0.04	0.05	0.05

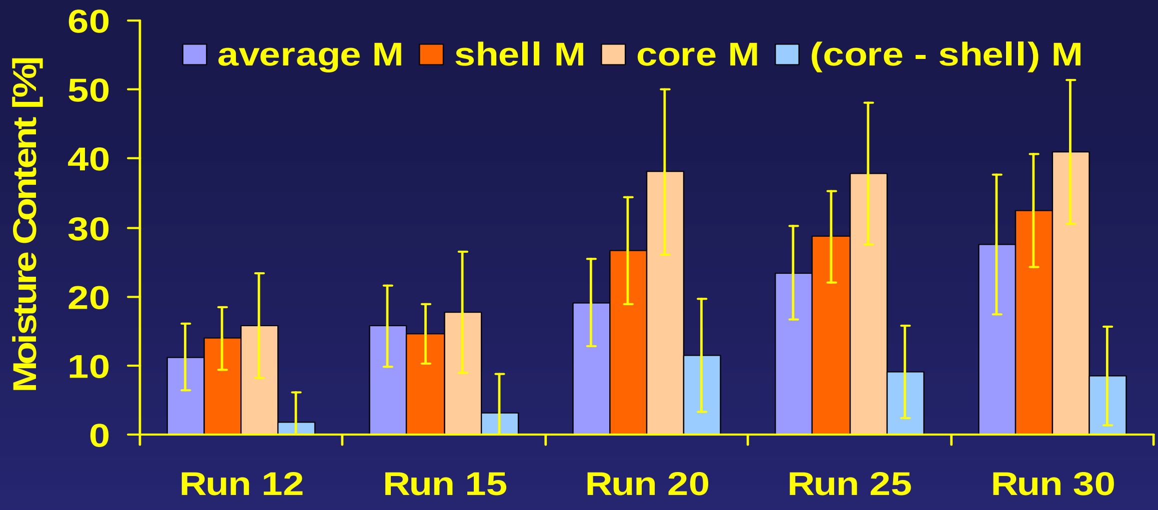
GREEN MC	Run 12	Run 15	Run 20	Run 25	Run 30
Mean (%)	52.97	64.55	51.79	55.41	67.31
St. dev.	17.82	21.53	16.37	16.05	20.81



Phase 1: Drying Times

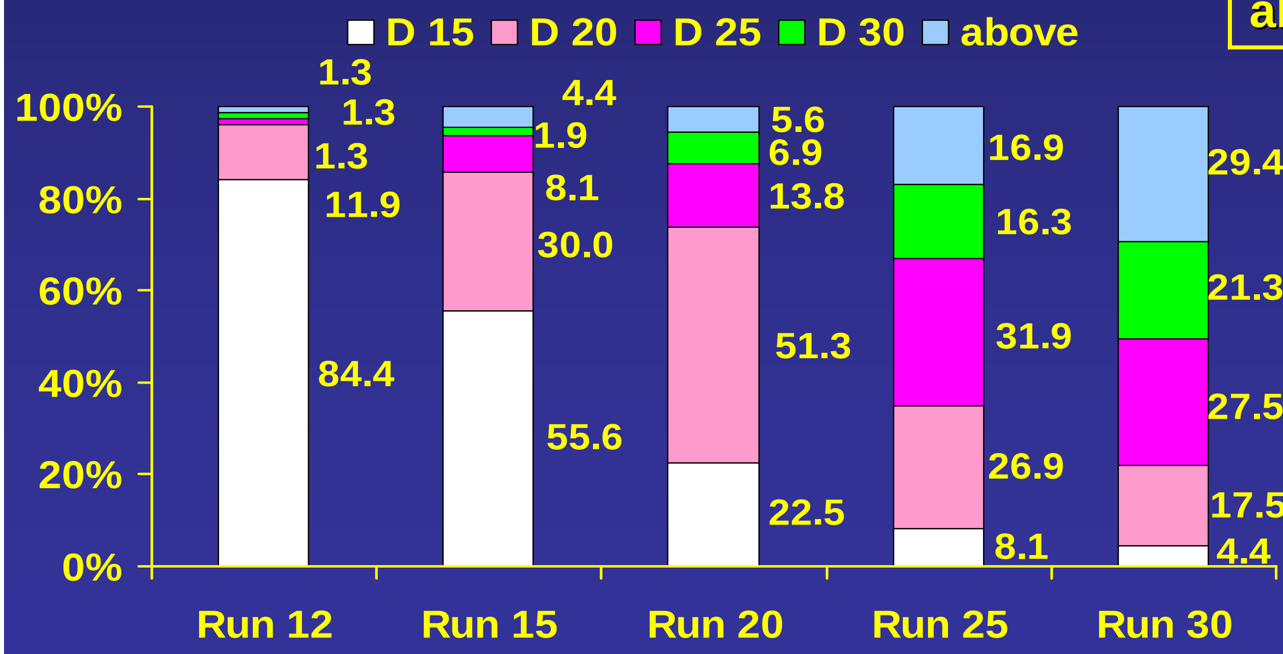


Phase 1:Moisture Classes Post-Drying



Moisture Classes

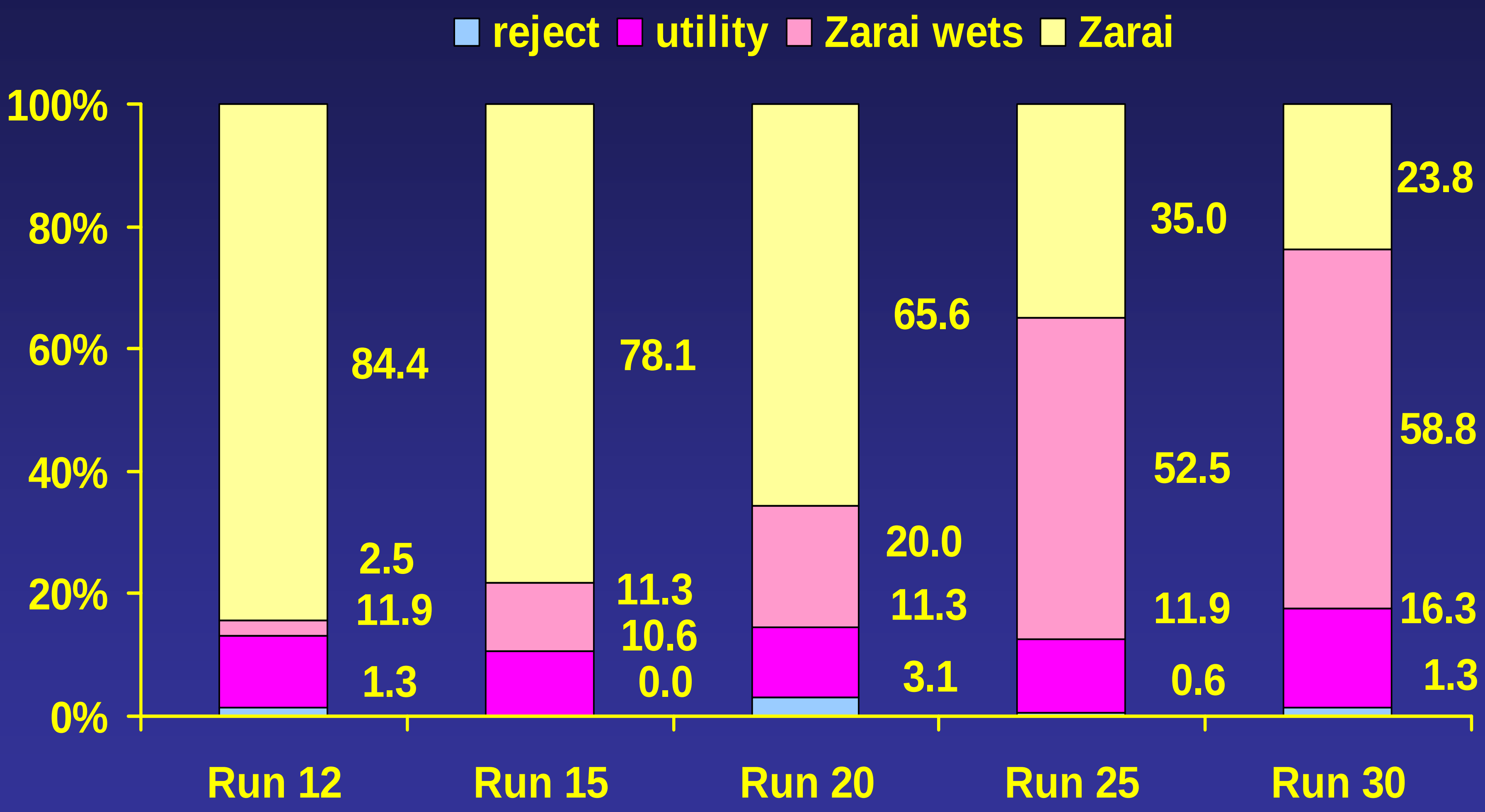
D15:	M<= 15%
D20:	15% < M < = 20%
D25:	20% < M < = 25%
D30:	25% < M < = 30%
above:	M > 30%



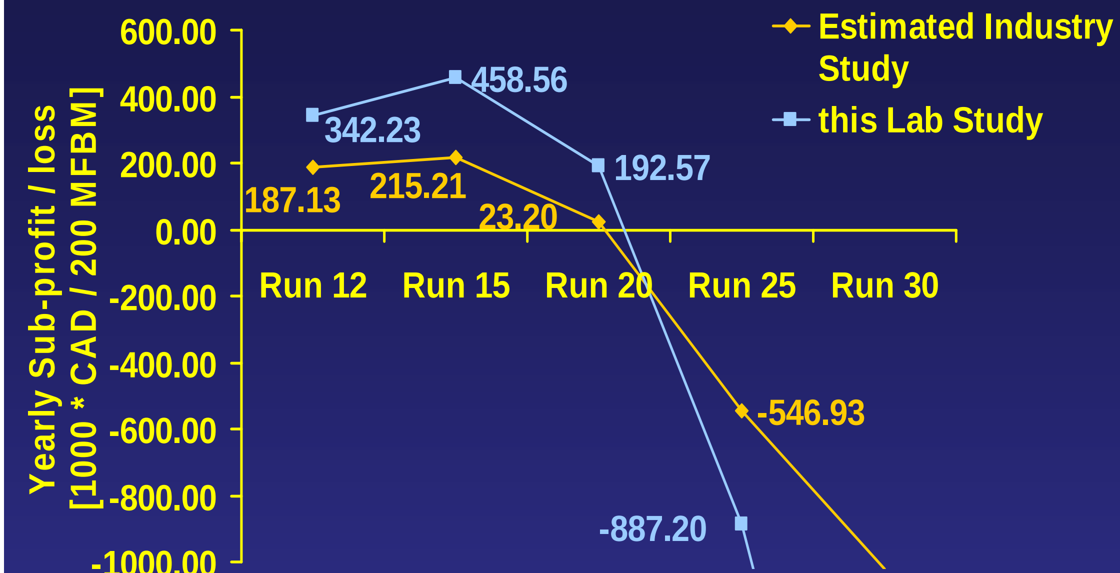
Phase 1: Shape Distortions

		before drying			after drying			difference			after planing		
	(mm)	twist	bow	diamonding	twist	bow	diamonding	twist	bow	diamonding	twist	bow	Diamonding
Run 12	**mean**	**1.9**	**2.6**	**0.7**	**3.7**	**3.4**	**1.8**	**1.8**	**0. 8**	**1.1**	**1.4**	**2.0**	**0.7**
	stdev	0.8	1.3	0.5	2.3	2.5	1.4	2.4	2.3	1.5	0.7	1.7	0.4
Run 15	**mean**	**1.4**	**2.3**	**0.5**	**3.1**	**3.1**	**1.1**	**1.7**	**0.9**	**0.6**	**1.4**	**1.6**	**0.8**
	stdev	0.7	0.9	0.4	1.7	2.1	0.9	1.8	2.1	0.9	0.7	0.9	0.5
Run 20	**mean**	**1.9**	**2.4**	**0.7**	**3.2**	**2.4**	**1.1**	**1.4**	**0.01**	**0.4**	**1.4**	**1. 8**	**0.7**
	stdev	0.7	0.9	0.5	1.5	1.2	1.1	1.7	1.3	1.3	0.7	0.9	0.5
Run 25	**mean**	**1.7**	**2.2**	**0.6**	**2.2**	**2.2**	**0.6**	**0.5**	**0.06**	**-0.02**	**1.6**	**1.9**	**0.6**
	stdev	0.8	1.1	0.4	1.0	1.5	0.6	1.3	1.6	0.8	0.7	1.3	0.6
Run 30	**mean**	**1.8**	**2.0**	**0.5**	**2.3**	**2.4**	**0.5**	**0.5**	**0.3**	**0.0**	**1.3**	**1.7**	**0.8**
	stdev	0.7	1.1	0.5	1.4	1.1	0.6	1.5	1.4	0.7	0.6	0.9	0.4

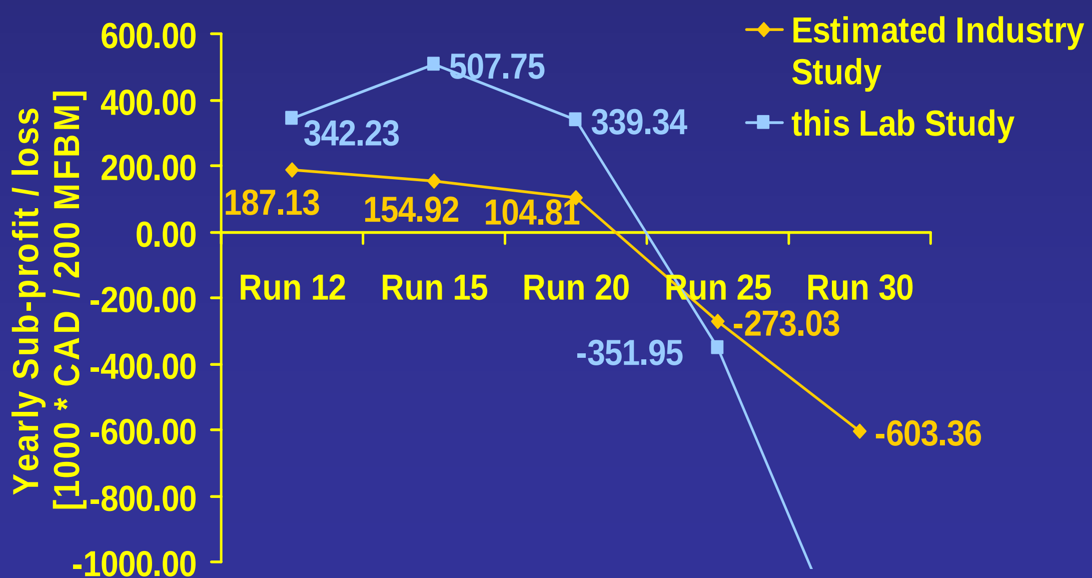
Phase 1: Lumber Grade Distributions



Phase 1:Sub-profit using lab scale results

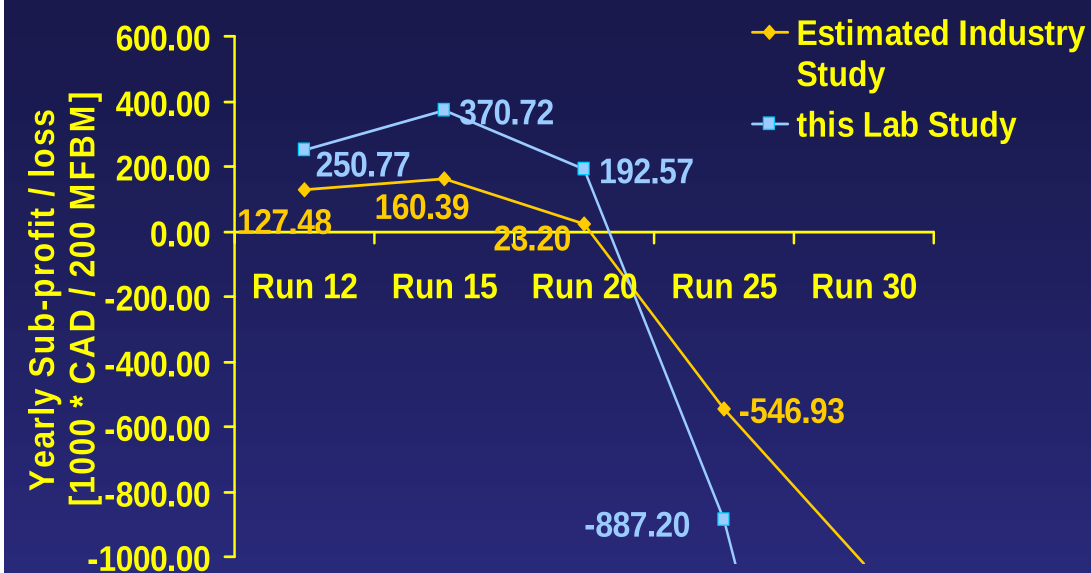


scenario 1: this study, no separating of wets

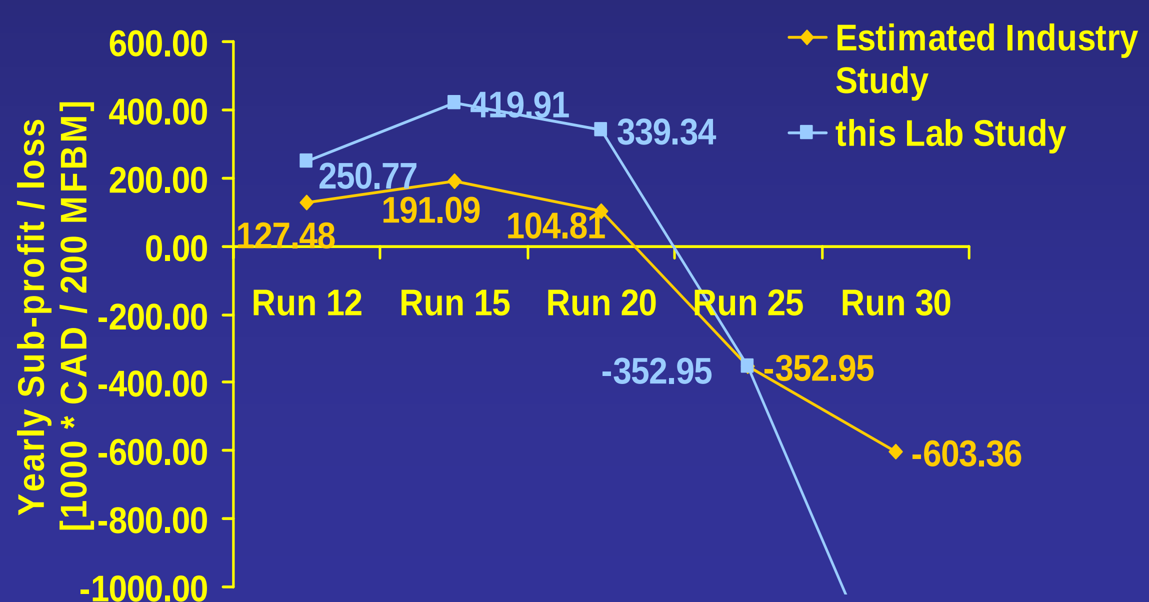


scenario 2: this study, separating of wets and sale with profit

Phase 1:Sub-profit using lab scale results



scenario 3: this study with adjusted degrade, no separating of wets



scenario 4: this study with adjusted degrade and separating of wets

CONCLUSIONS for Phase 1: Lab Scale Study

- The most profitable target moisture content identified in this study was **15%,** followed by **12%** and **20%.** The **25%** and **30%** targets produced negative profits due to higher wet percentages.
- The yield of the *Zairai* grade was above 85%, independent of the target moisture content levels
- In all runs, the drying shape distortions were significant, but the grading results for five test runs showed, that degradation in this study was not from drying losses, but resulted from **green wood quality**.

CONCLUSIONS for Phase 1: Lab Scale Study

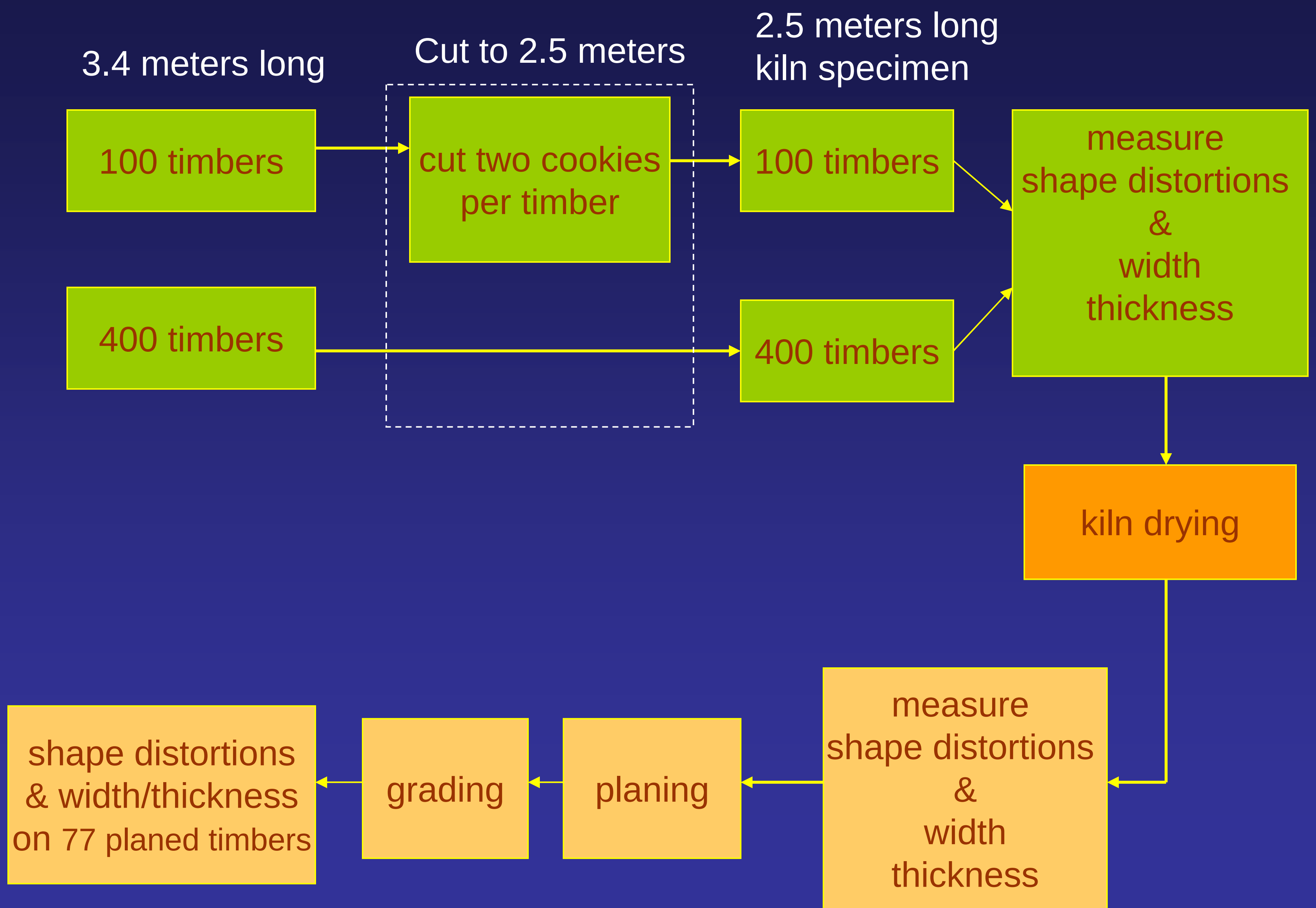
- The timbers were planed straight and the shape distortions exhibited no significant difference between runs after the wood was planed to the target size of 105mm cross-section.
- The sapwood, compression wood and pith location did not expose a direct threat to the drying quality and shape straightness of timber specimens tested.
- The percentage of wets in the population exponentially increased at target moisture content level of 18% and above.

Phase 2: Industrial Scale Study

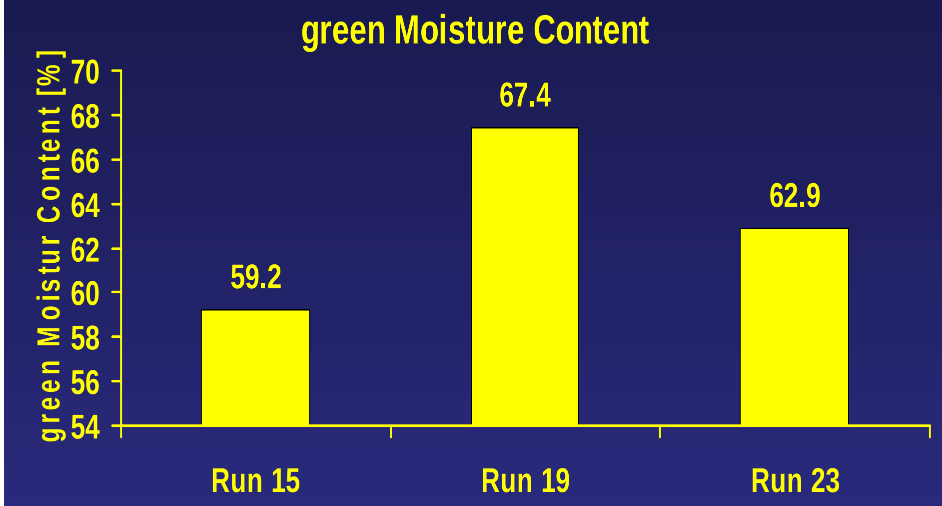

natural gas fired kiln

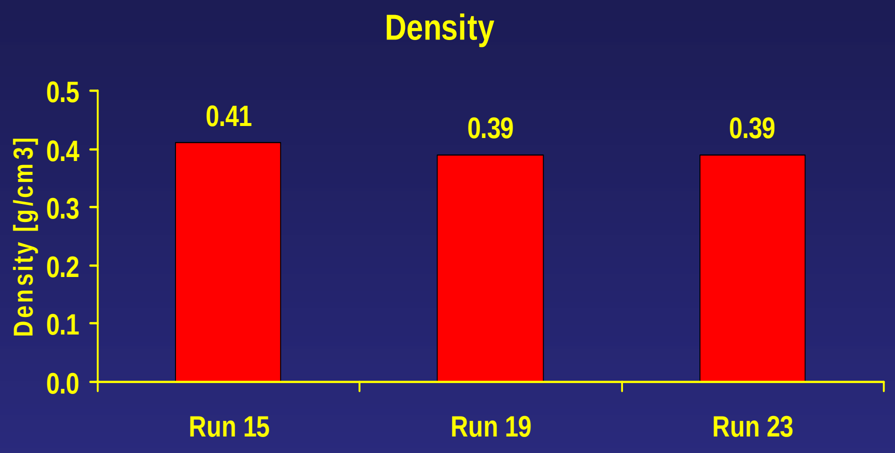
target Moisture Contents = 15%, 19%, 23%

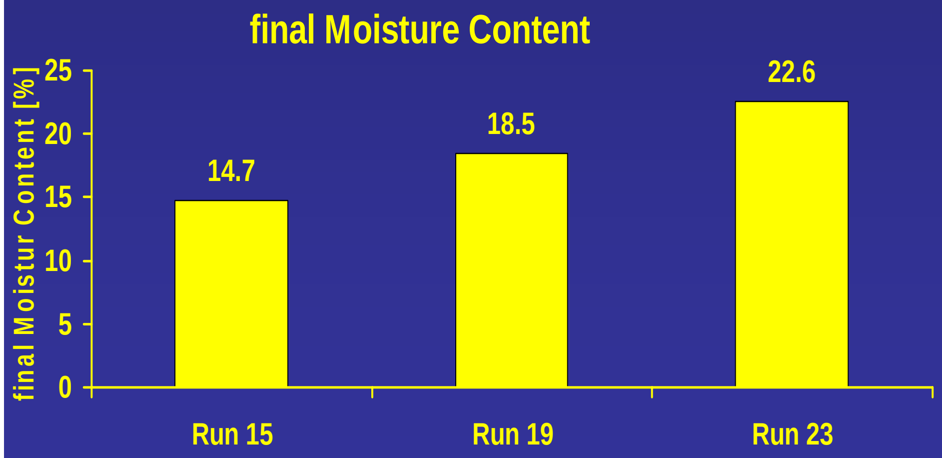
Phase 2: Flowchart

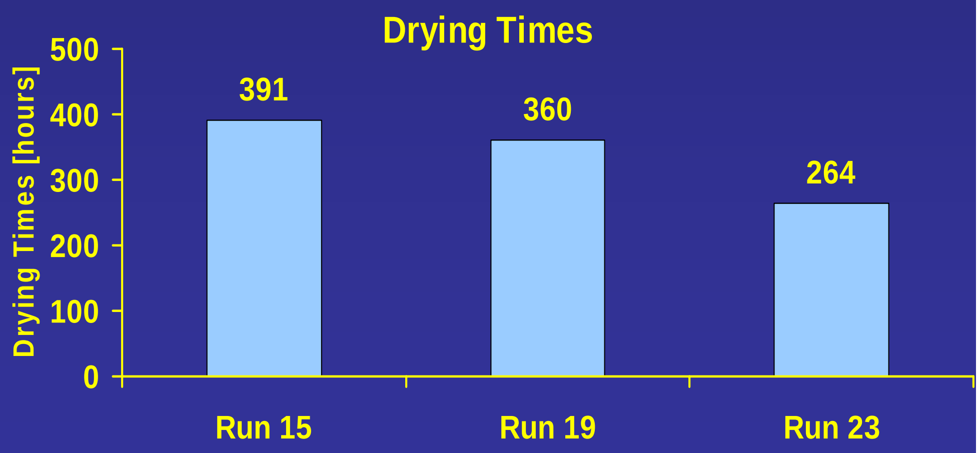


Phase 2: Moisture Contents, Density and Drying Times





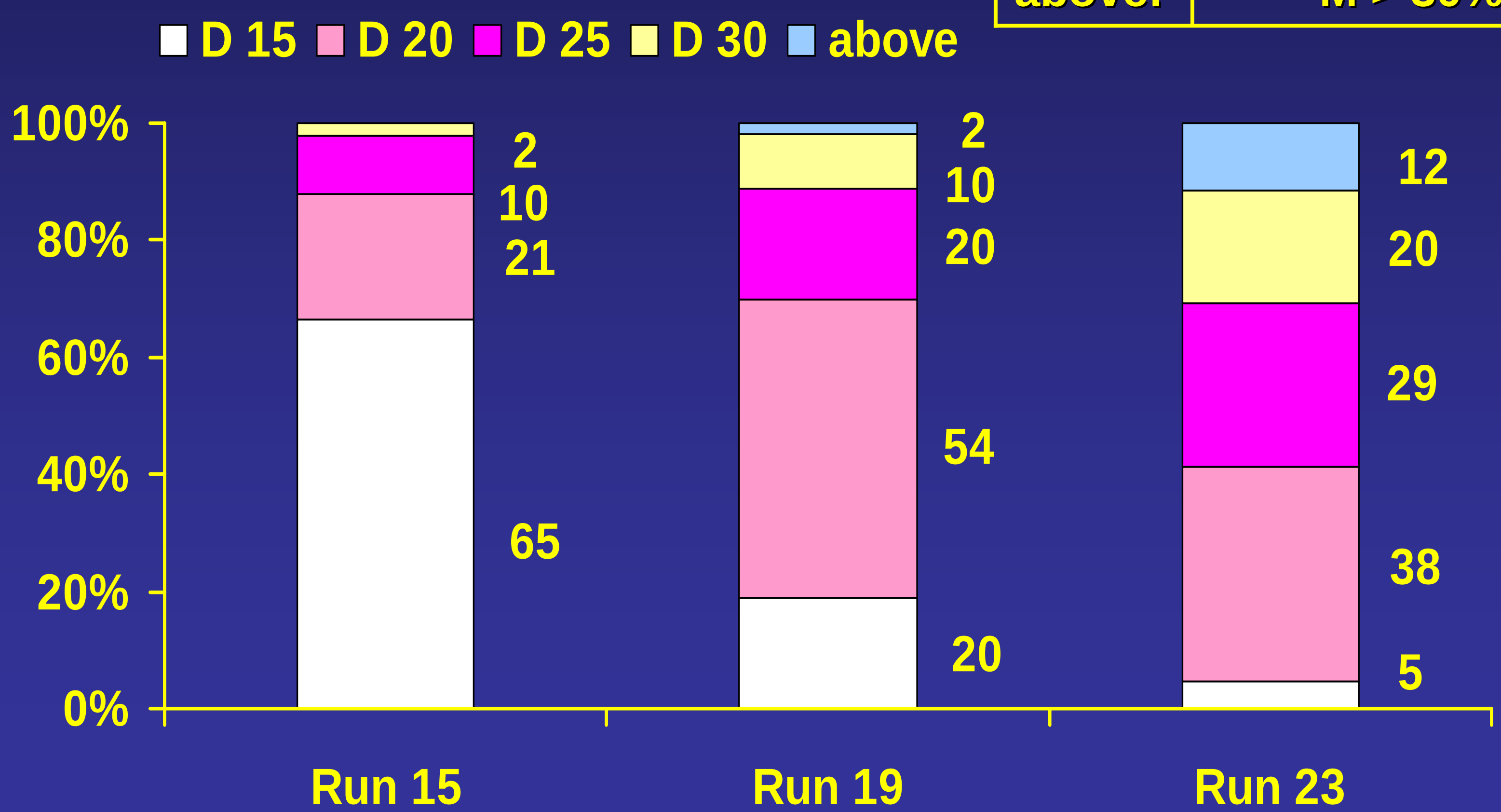




Phase 2: Moisture Classes

Moisture Classes

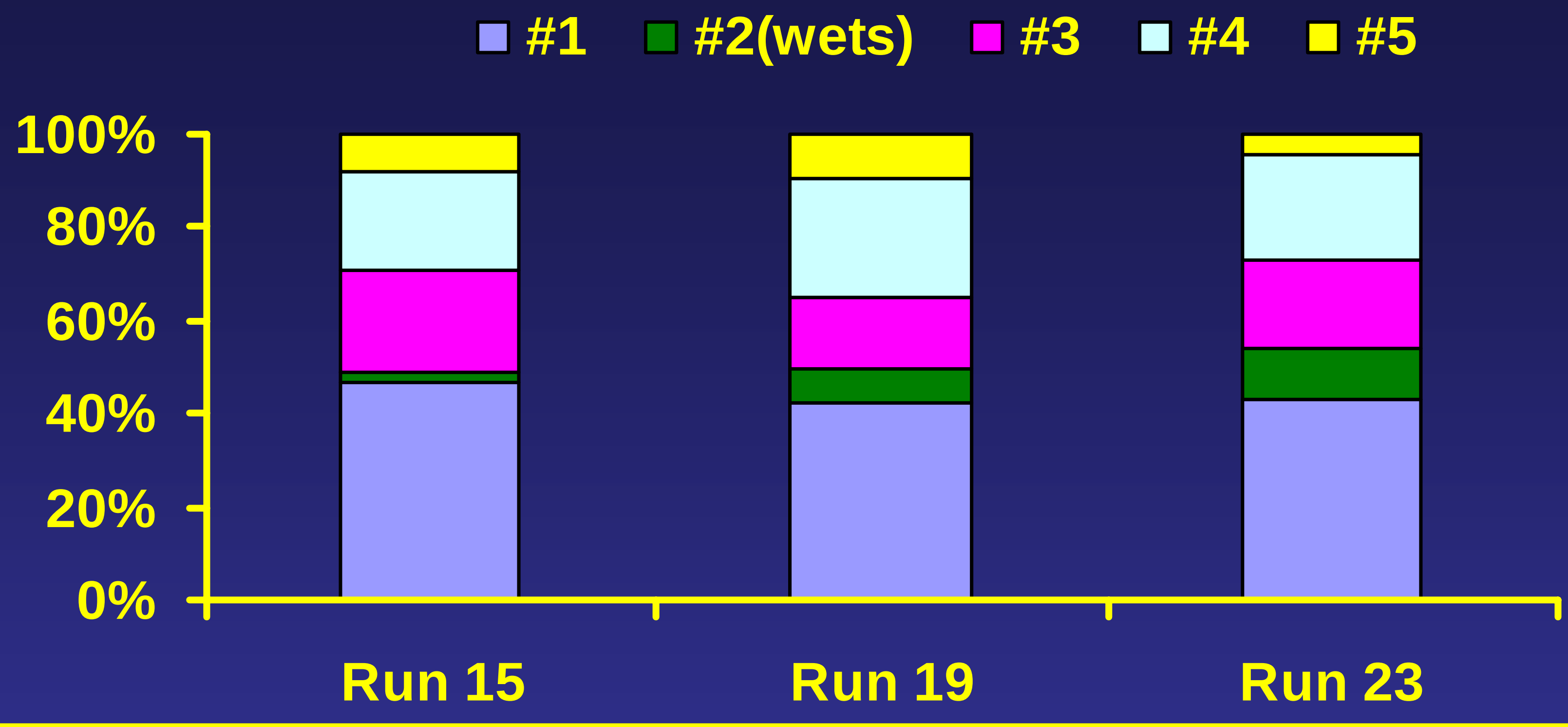
D15:	M<= 15%
D20:	15% < M < = 20%
D25:	20% < M < = 25%
D30:	25% < M < = 30%
above:	M > 30%



Phase 2: Shape Distortions

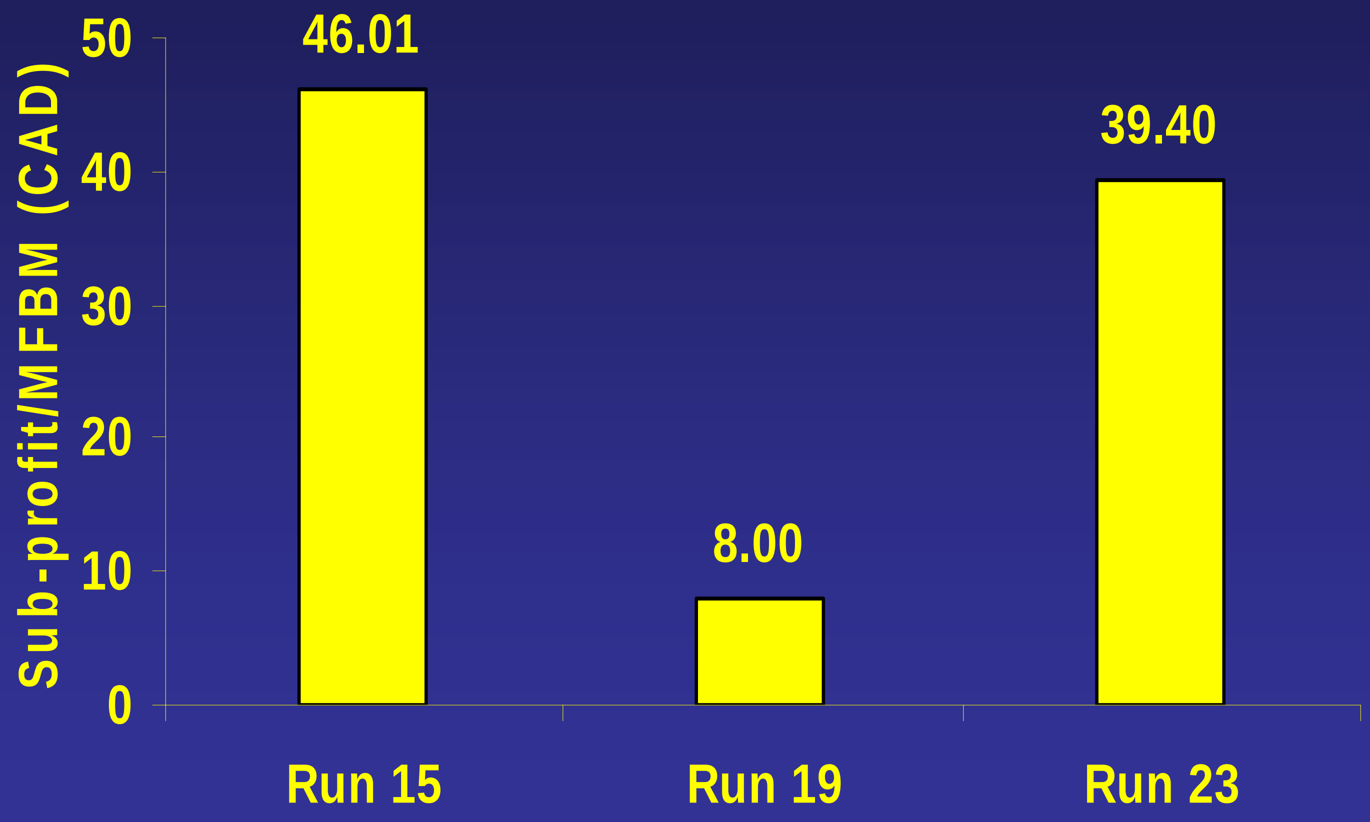
[mm]		before drying			after drying			difference			after planed		
		twist	bow	diamonding	twist	bow	diamonding	twist	bow	diamonding	twist	bow	diamonding
Run 15	mean	1.5	2.3	0.3	2.7	2.5	0.8	1.2	0.2	0.4	1.1	1.9	0.2
	st.dev.	0.8	1.3	0.2	1.3	1.5	0.8	1.5	1.5	0.8	0.5	1.3	0.2
Run 19	mean	1.4	2.6	0.4	2.8	2.8	0.5	1.4	0.2	0.1	0.9	2.1	0.3
	st.dev.	0.7	1.8	0.4	1.6	1.6	0.5	1. 8	1.6	0.6	0.7	1.4	0.2
Run 23	mean	1.4	2.3	0.3	2.3	2.5	0.6	0.9	0.2	0.3	1.1	1.5	0.3
	st.dev.	0.7	1.4	0.3	1.4	1.6	0.6	1.5	1.6	0. 7	0.5	0.9	0.3

Phase 2: Lumber Grade Classes



	#1	#2(wets)	#3	#4	#5
Run 15	46.4	2.2	22.1	21.5	7.8
Run 19	42.3	7.0	15.8	25.7	9.2
Run 23	42.7	11.5	18.6	22.7	4.5
Selling prices					
CAD/MFBM	920	580	760	360	295

Phase 2:Sub-profit using industry scale results



Conclusions for Phase 2: Industrial Scale Study

- Drying resulted in significantly greater twist, bow, and diamonding, except for bow in Run 15 and Run 19, but most degrade resulted from green wood defects (shake first), not from the drying process.
- Target of 15% is the most profitable compared to other two runs, because of higher top grades realization.
- Profit seemed to be sensitive to grade realization first and wets population second, if target M<20%.

Summary

- Drying times are longer with lower target moisture content
- Target moisture content of 15% seems to be the most profitable one
- Drying quality depends on green wood quality
- Increasing in wets population with higher target moisture contents
- Grade realization independent of target Moisture Content

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- Coast Forest and Lumber Association (CFLA)
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- Weyerhaeuser Canada

Questions?