TIMBER MEASUREMENTS SOCIETY

- Fall Meeting
- October 28-29 2008

Review of Various Wood Measurement Methods Used Today in the Pulp & Paper Industry

Christian Paccot – Woodtech, Chile

Summary

- Woodtech
- Why measure well?
- Comparing units
- Comparing methods
- Conclusion

• Woodtech

MEASUREMENT SOLUTIONS

- **Specialist in Automatic Wood Measurement Systems since 1990**
  - Created from Excelsys' association with the largest Financial Group in Chile - main shareholder of ARAUCO

ARAUCO

- **Products specifically for wood measurement on Trucks**
  - Measurement of solid and frame volume, as well as the biometric characteristics of the wood.
- **Presence today : Latin American → Product for the World**
- **Main Partners**
  - Strategic partnership with:
    - SKS Vision Systems (Finland)
    - Mogai (Brazil)
  - Endeavor enterprise

SKS VISION SYSTEMS

MOGAI

endeavor CHILE

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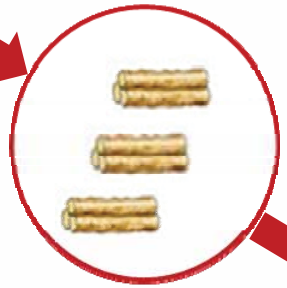
•Typical Units Used

Forest Solid Volume

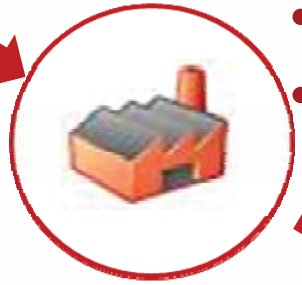
Woodyard

- Frame Volume
- Solid Volume
- Tons



Mill

- Solid Volume
- Tons
- BDT



Market BDT

Differents Units Used at differents steps of the value chain

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Why Measurement of Wood is important?

Cost of the wood:

→ > 50% Production Cost
→ 20 – 100 US$ Millions/Year

Approximate breakdown of the cost:

- 1/3 Cost = Wood
- 1/3 Cost = Harvest
- 1/3 Cost = Transport

THE CORRECT MEASUREMENT OF WOOD IS IMPORTANT

… even if mill owns the forest

Typical Measurement Methods and Units

The main raw material…

- Typical Measurement Methods and Units

- is measured like this….

- Typical Measurement Methods and Units

- Or is measured like this….

- **weight SCALE**

- Typical Measurement Methods and Units

- Or is measured like this….

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Some Consequences – Units /Methods Problems

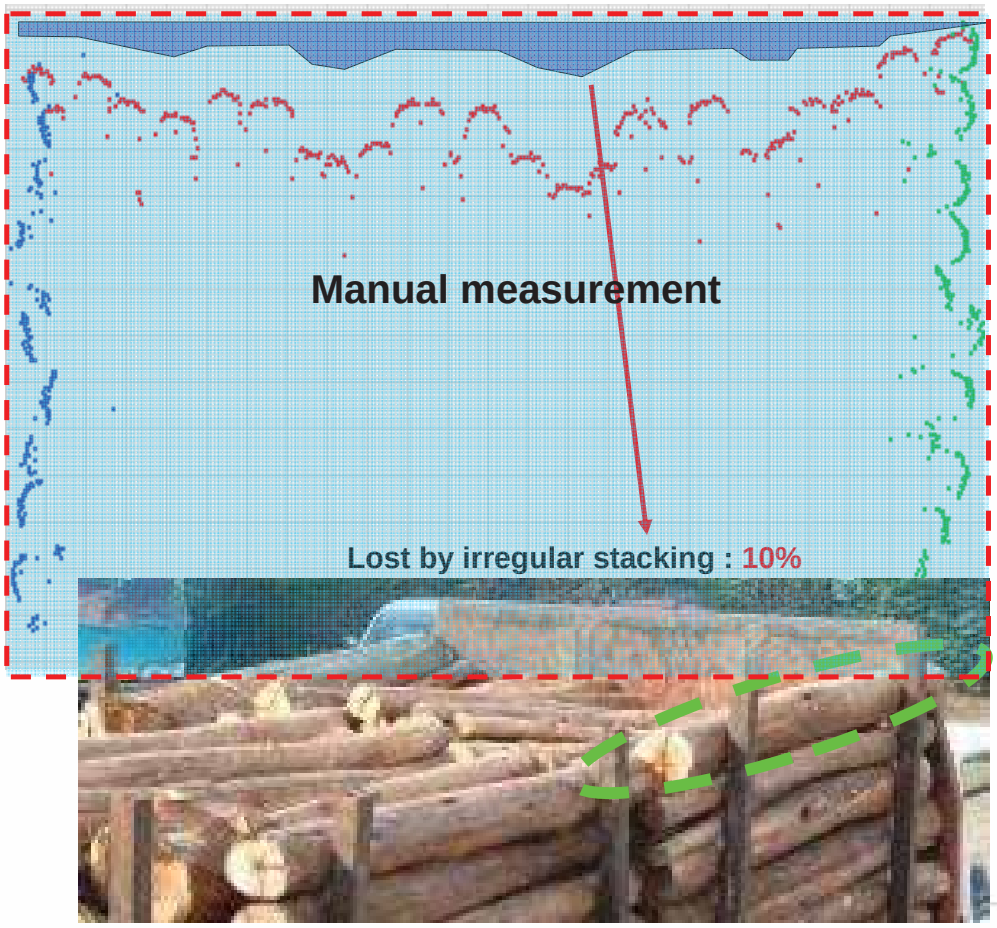
- Wood Measurement Costs
- Important differences between:
  - Forest Inventories ←→ Wood at the mill
  - Wood received ←→ Wood Payed/Mill inventories
- Perverse incentives → Non-equitable payment
- Fraud Risks

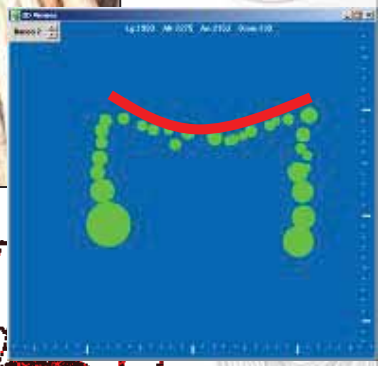
IMPORTANT EFFECTS ON WOOD COST
→ ON PRODUCTION COSTS

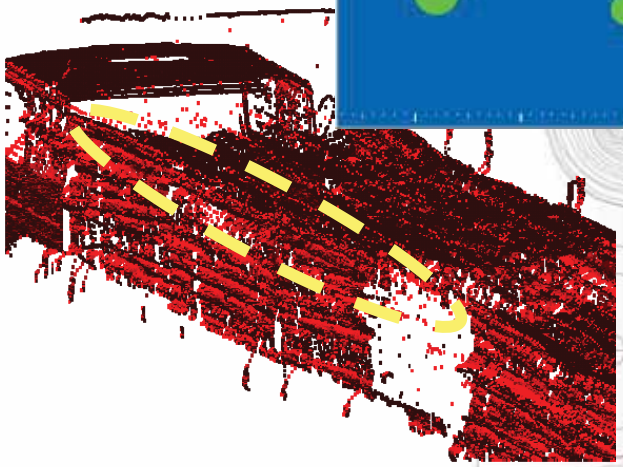
- Samples of Frauds

- **IMPORTANT EFFECTS ON WOOD COST**
- **→ ON PRODUCTION COSTS**

Samples of Frauds







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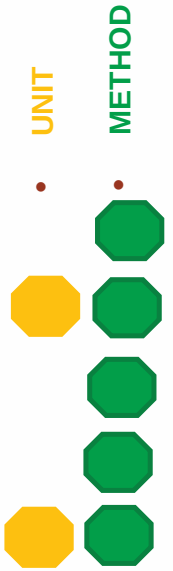
•Why measure well?

*"The unit of quantity must be **OBJECTIVE, REPRODUCIBLE, EASILY AND COST-EFFECTIVELY DETERMINED** and **FAIR** to both the buyer and seller."*

•Measuring pulpwood quantity, Russell Morkel (1998)



1. **Objective:** Does not depend on human factors.
2. **Reproducible:** No variation with exogenous factors.
3. **Efficient:** Quick and low cost.
4. **Fair:** Equitable for both sides…
5. **Incentive:** Does not create perverse incentives

Agenda

- Woodtech
- Why measure well?
- Comparing units
- Comparing methods
- Conclusion

Comparing units

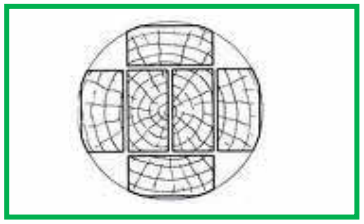
The measure must be directly related to the value of the product traded.

Green Wood

=

Dry Wood

Biometric Characteristics



VALUE

+

Water

NO VALUE

Objective is to measure only the VALUE

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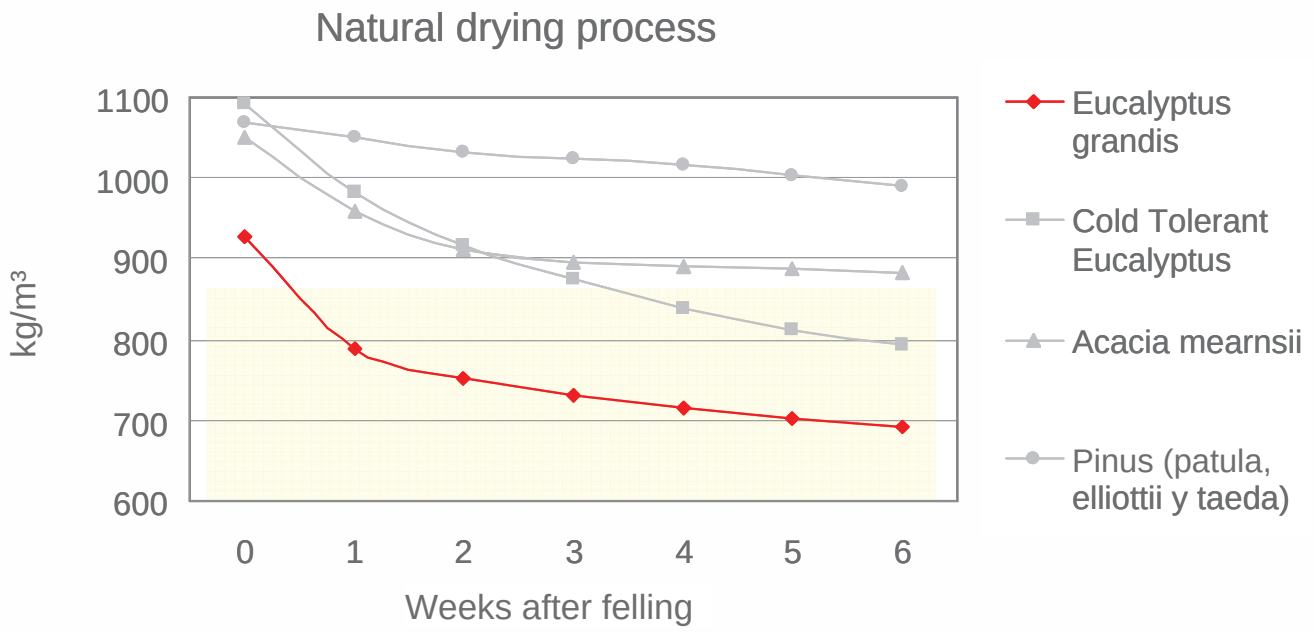
Agenda

- Woodtech
- Why measure well?
- Comparing units
  - Weight
  - Frame Volume
  - Solid Volume
- Comparing methods
- Conclusion

Value Wood by weight

Moisture content: Loss of water = Loss of Wegth



E. grandis loses 49% of its water (**25% of its weight**) in 6 weeks.

The natural drying process is not constant: it depends on the species, the season, the temperature, the environmental humidity, among other factors.

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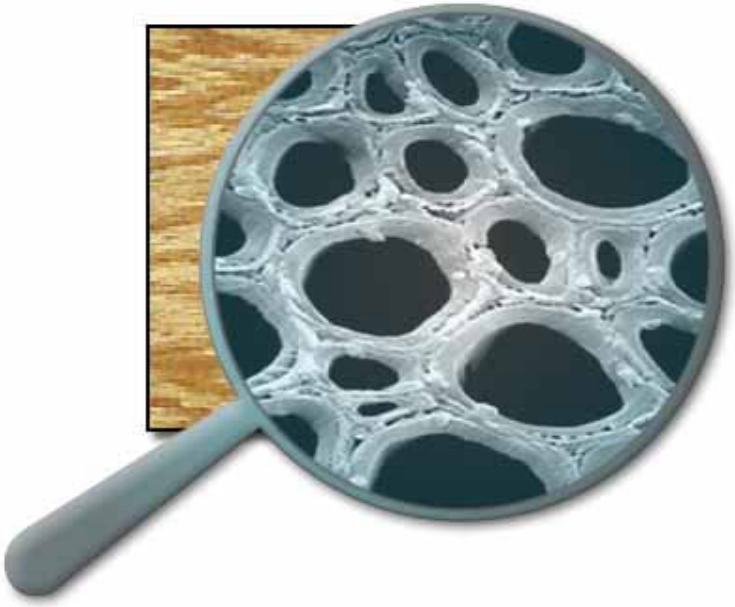
Value Wood by WEIGHT

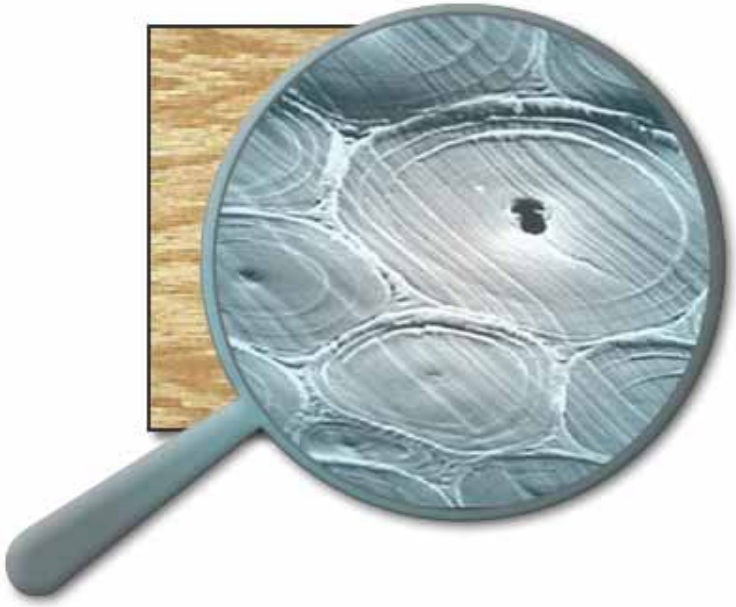
Weight of the wood depends on:
Moisture content & Density

The density of wood varies with age.

Young wood



12-year-old wood



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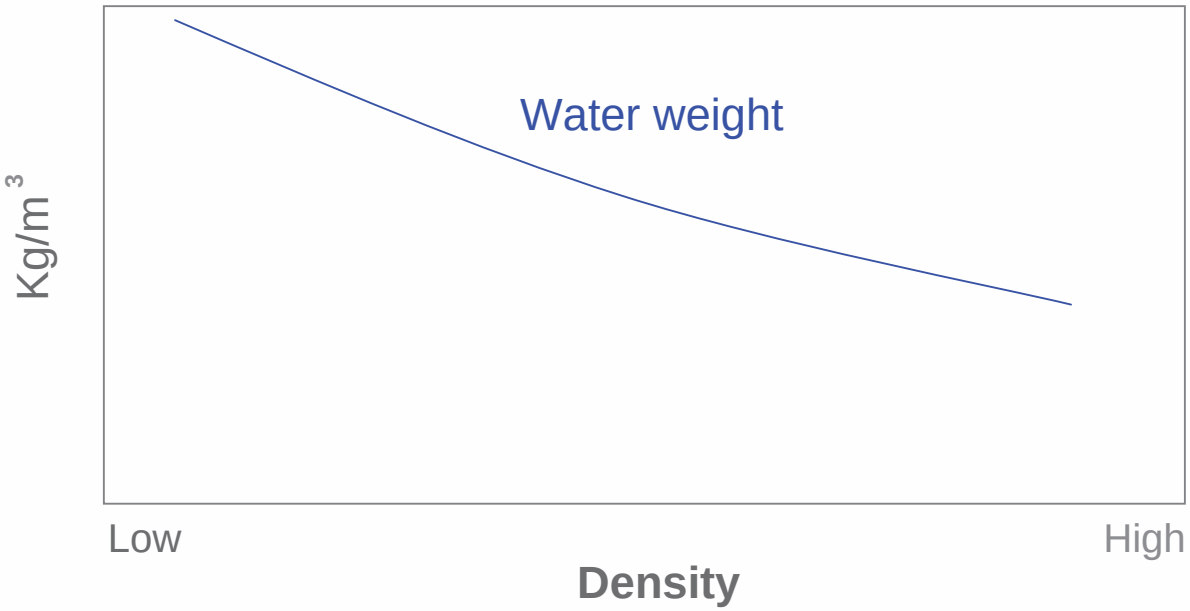
Value Wood by weight

Moisture content depends on density

Wood with a greater density → less moisture content

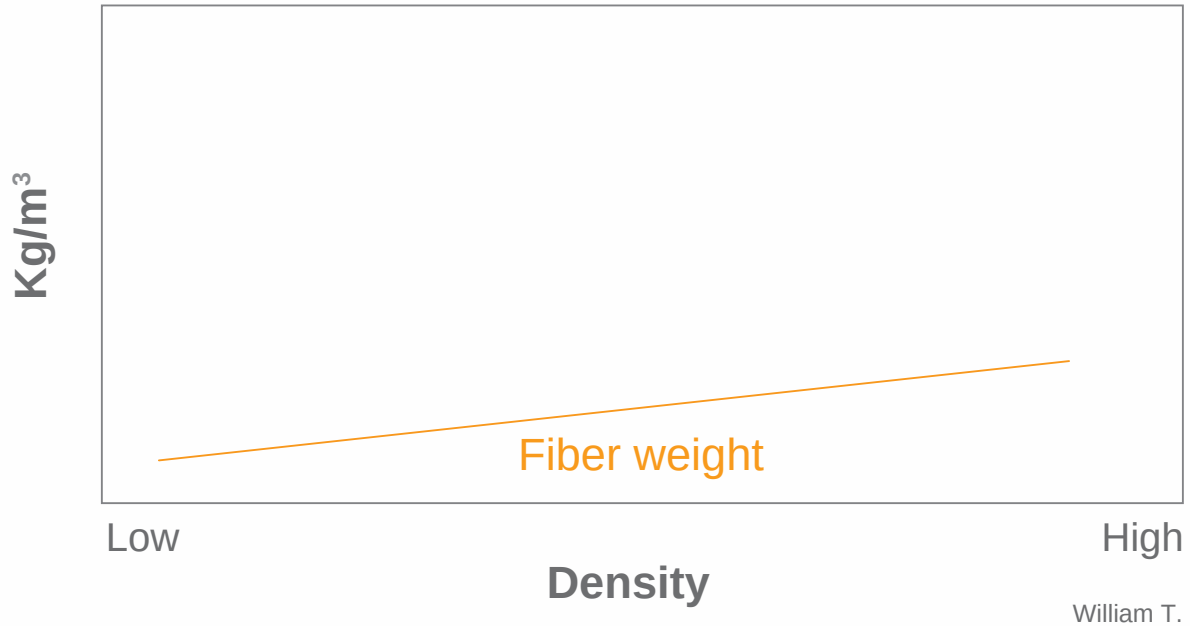


William T. Simpson (1993)

Value Wood by weight

Moisture content depends on density

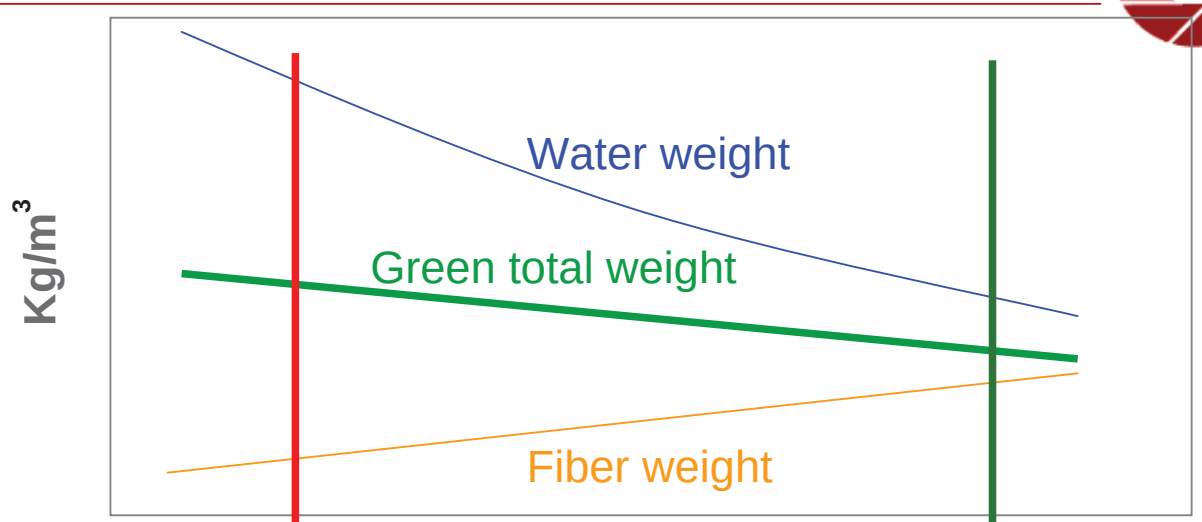
Wood with greater density → Higher weight/ m^3



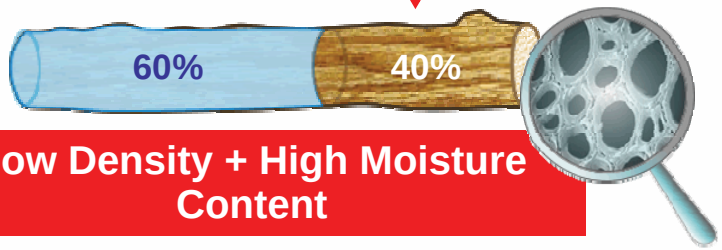
William T. Simpson (1993)

Value Wood by weight

Wood Density effect on Moisture Content



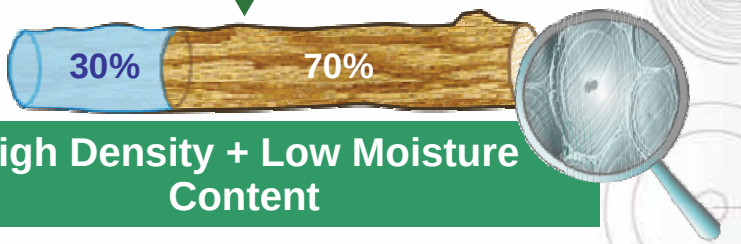
William T. Simpson (1993)



Low Density + High Moisture Content

WEIGHT

≈



High Density + Low Moisture Content

WEIGHT

VALUE FOR PROCESS ≠ VALUE FOR PROCESS

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Comparing units - WEIGHT

→ Weight is not related to VALUE – water and density

→ Weight measurement is not reproducible in time - drying

→ Weight produces perverse incentives – transportation costs

SAWMILLS:

→ Weight doesn't provide information on wood biometrics

WEIGHT is not an adequate unit for wood Measurement

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Agenda

- Woodtech
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  - Weight
  - Frame Volume
  - Solid Volume
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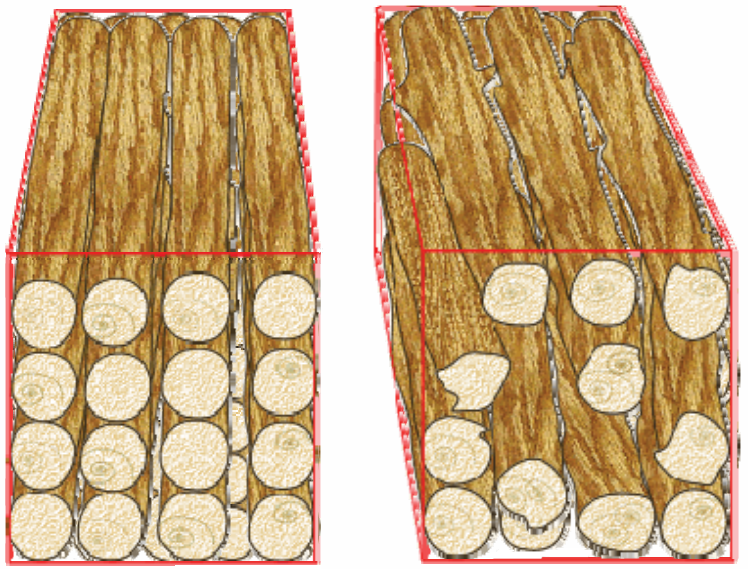
Value Wood by FRAME VOLUME

- Frame Volume measurement includes air spaces between logs.
- Air spaces depend of:
  - Diameter distribution
  - Arrangement of logs in the pile
  - Length of the logs
  - Knots, crook and sweep factors



FRAME VOLUME is not an adequate unit for wood measurement

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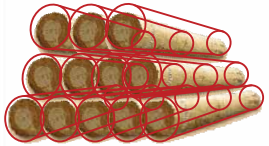
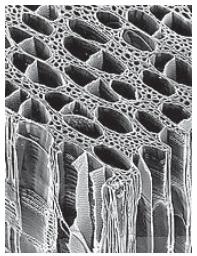
Comparing units

Solid Volume



SOLID VOLUME

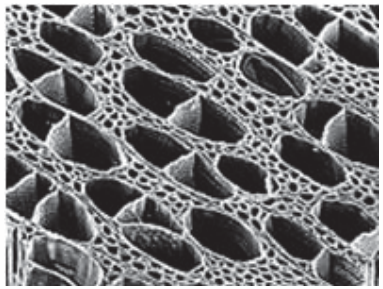
=



Fibre
VALUE

+

Water
NO VALUE



…BUT VOLUME REMAINS CONSTANT

Solid Volume is related to fibre quantity (not water quantity)

Solid Volume is related to Value

Solid Volume is fair, no perverse incentives

Solid Volume is reproducible

"The greatest advantage of measuring pulpwood by volume is that volume remains unchanged […] from point of measure to point of processing"

Measuring pulpwood quantity, Russell Morkel (1998)

SOLID VOLUME is a reasonable unit for wood measurement

.....but it is not a value easy to measure

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Agenda

- Woodtech
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Comparing methods → Solid Volume

Indirect Methods with Sampling

1. Sampling Systems
2. Frame Volume
   - + Conversion Factor
   - + Piece Scaling
3. Weight Scales
   - + Piece Scaling
   - + Immersion systems

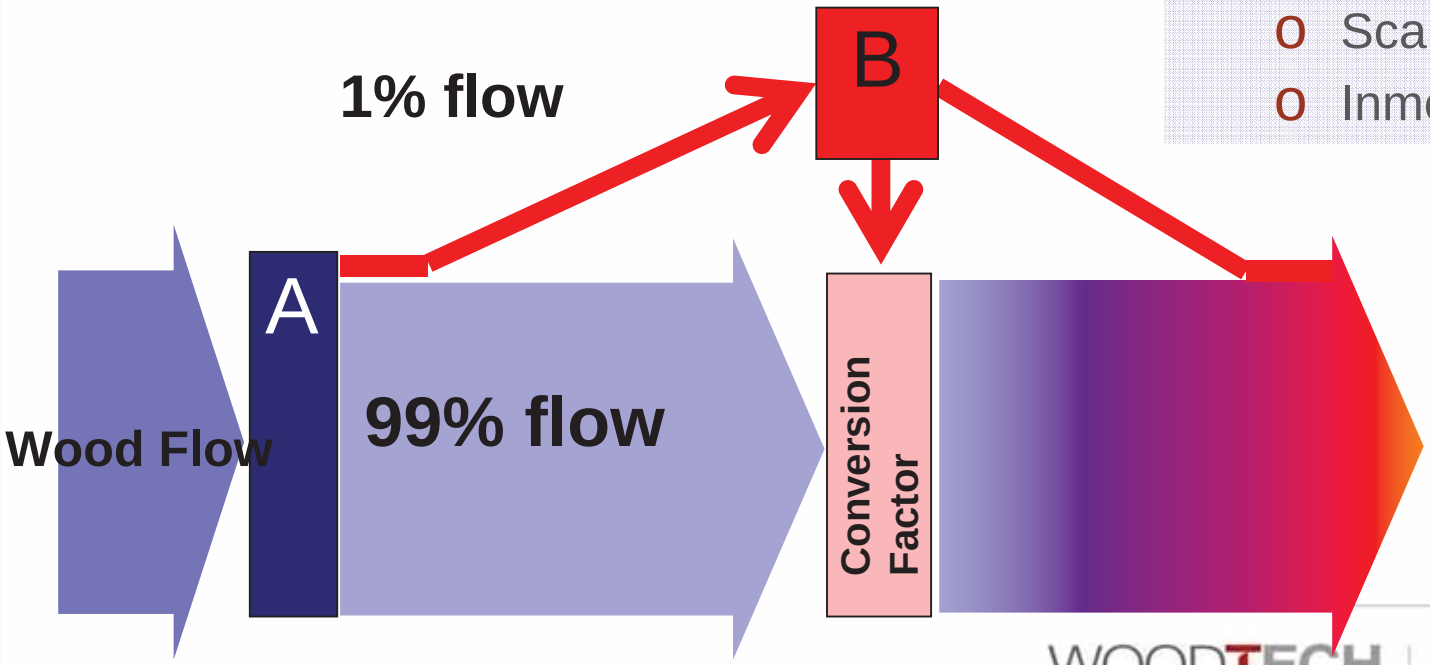
Direct Measurement Methods

1. Drive-Through Scanners

Comparing Methods – Sampling

Sampling System: 2 distinct measurement methods:

- Primary method: 99 % of flow : Cost driven
  - Frame Volume
  - Weight
- Secondary method:1% of flow:Precision driven
  - Conversion Factor
  - Scaling
  - Inmersión



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Comparing Methods – Sampling

Results could be manipulated by changing sampling intensity along the year.

		Regular Sampling		Biased Sampling	
	Density	Trucks Sampled	Cumulated Conversion factor	Trucks Sampled	Cumulated Conversion factor
January	900	10	900	20	900
February	880	10	1242	18	891
March	840	10	1332	18	874
April	730	10	1072	4	865
May	690	10	913	4	854
June	660	10	805	4	842
July	640	10	726	4	831
August	600	10	666	4	819
September	660	10	621	4	811
October	710	10	587	4	806
November	840	10	671	18	812
December	880	10	747	18	822
Total:		120		120	
difference:	10%				

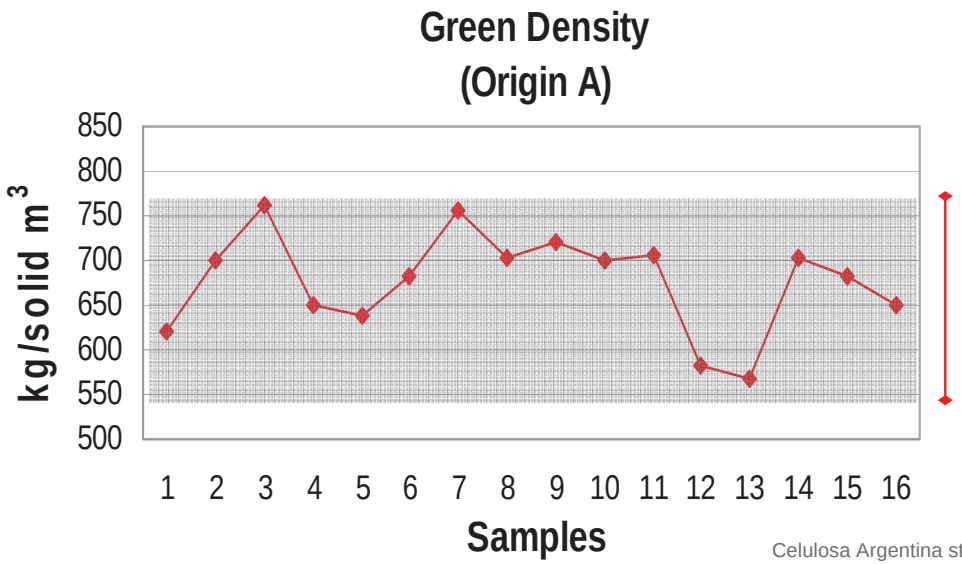
In this example, 120 trucks have been sampled in each case

→ 10 % Difference in the Conversion Factor

INDIRECT METHOD

Weakness of an extrapolation factor from sampling

There are large differences in density among samples of wood from the same origin



Differences of up to 28%

Celulosa Argentina study (2005)

The calculation of a conversion factor based on *one* truck is not representative for *other* trucks.

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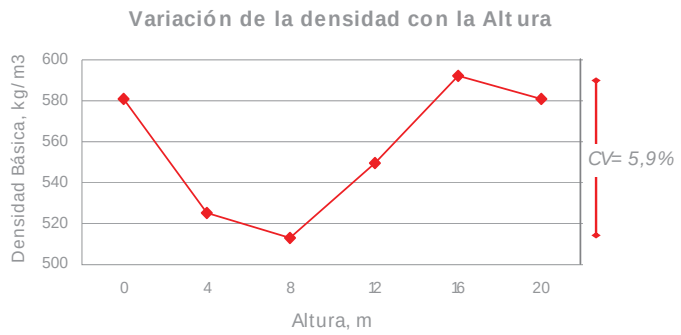
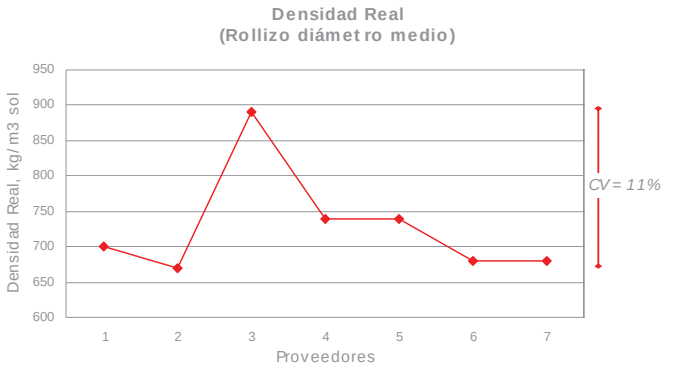
INDIRECT METHOD

Weakness of an extrapolation factor from sampling



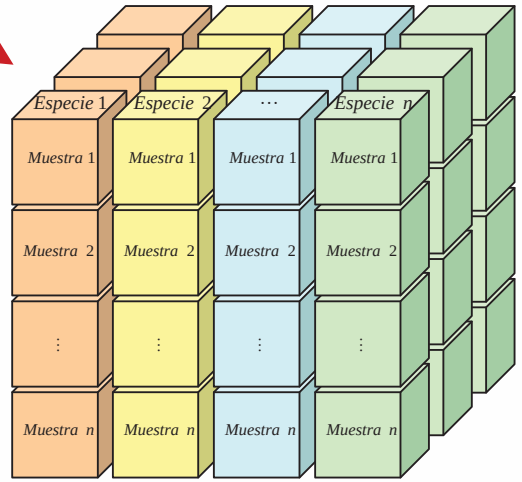


Variation from the same tree

Variation from the same origin

Variation between providers

REQUIRES MANY CONVERSION FACTORS



In practice: Requires a VERY high sampling rate

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Comparing methods → Solid Volume

Indirect Methods with Sampling

1. Sampling Systems
2. Frame Volume
   - + Conversion Factor
   - + Piece Scaling
3. Weight Scales
   - + Piece Scaling
   - + Immersion systems

Direct Measurement Methods

1. Drive-Through Scanners

•Comparing methods

•Manual Frame Volume

- Theoritically easy: X * Y * Z ….. What about practice?

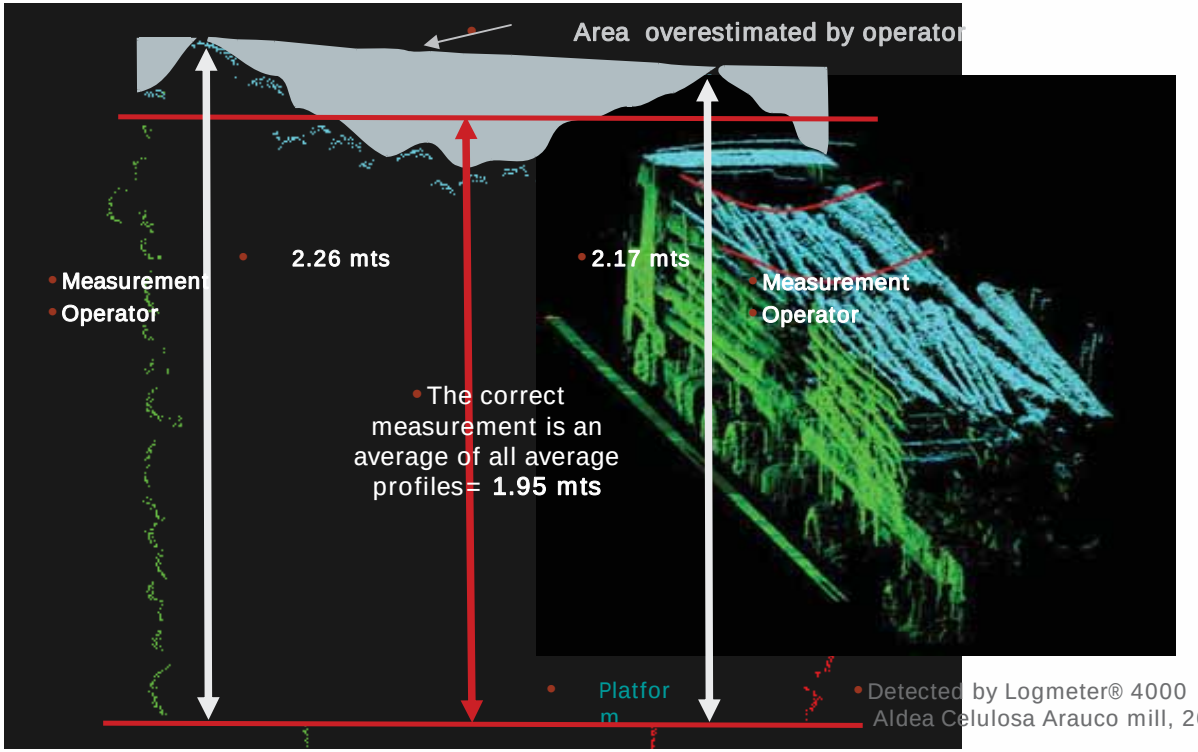
•Comparing methods

•Manual Frame Volume

- What is the **height** of this truck?

Comparing methods

Manual Frame Volume



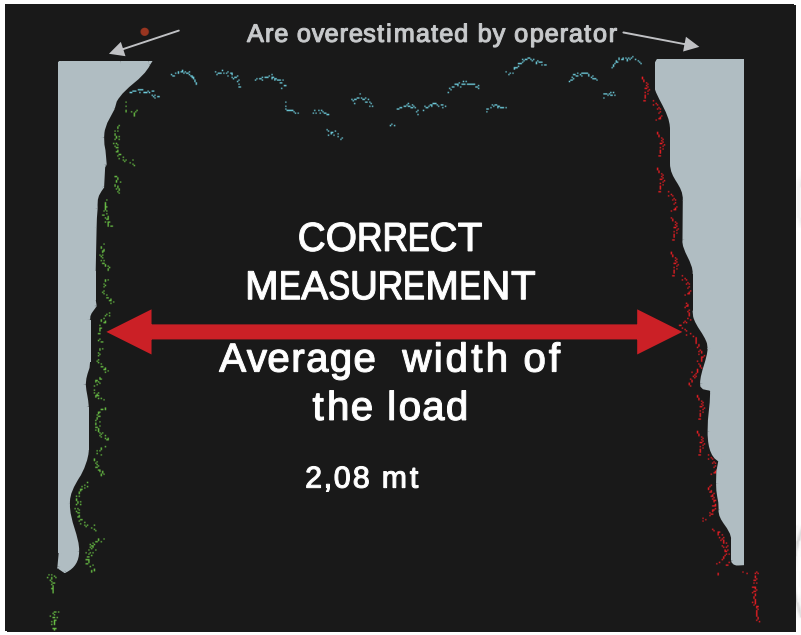
Detected by Logmeter® 4000 Nueva Aldea Celulosa Arauco mill, 2008.

Height overestimation: **+ 12.8%**

•Comparing methods

•Manual Frame Volume

- What is the **width** of this truck?

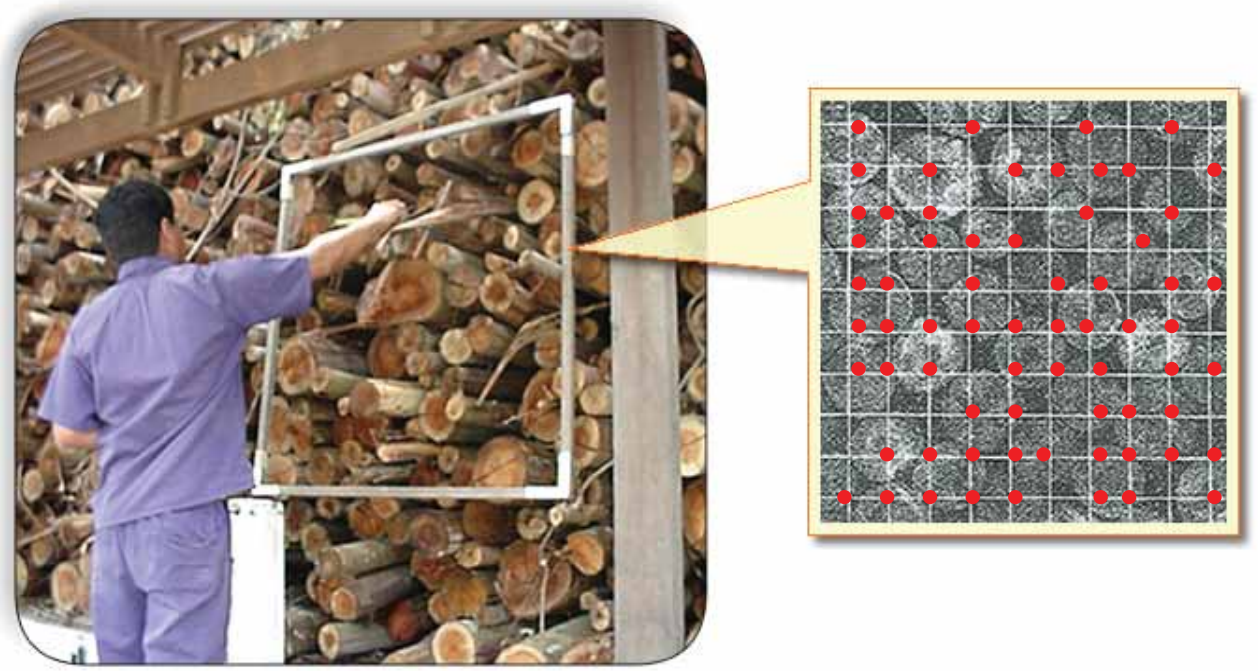


• Detected by Logmeter® 4000 in Nueva Aldea mill, 2008.

INDIRECT METHODS

Frame to Solid

Grid Method



100-point grid
Operator selects the area

→ **CALCULATION OF THE CONVERSION FACTOR**

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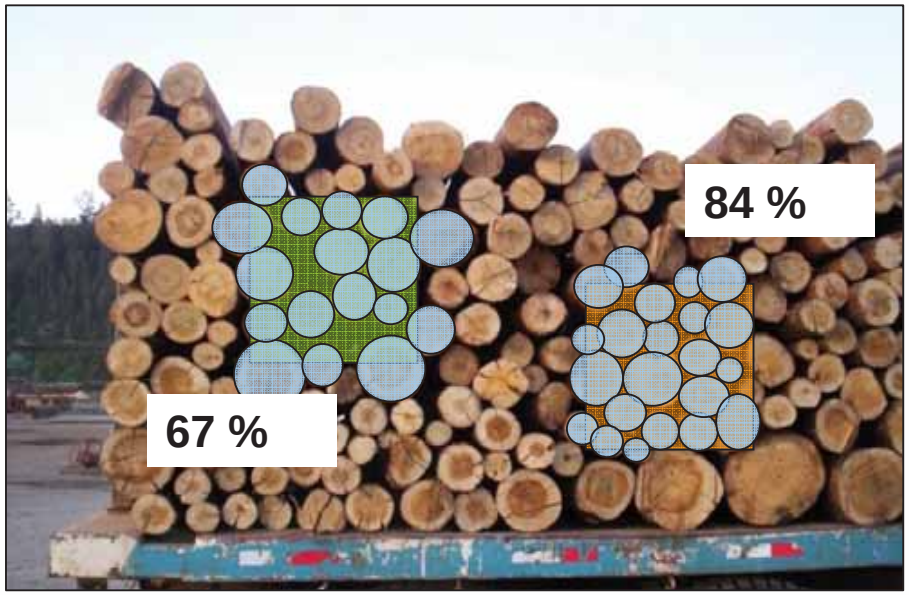
INDIRECT METHODS

Frame to Solid

Image Analysis



The conversion factor depends on the area selected for the image analysis and how representative the sample is.

Comparing methods

Frame Volume+ Piece Scaling

- Used in some scandinavian countries
- Frame volume is a better unit than weight
- The fit between frame volume/solid volume (15% variability) is much tighter than the weight/solid volume one (100% variability)
- More resource-demanding than weight scale sampling system but better and fairer results can be achieved.

Comparing methods

Manual Individual Scaling

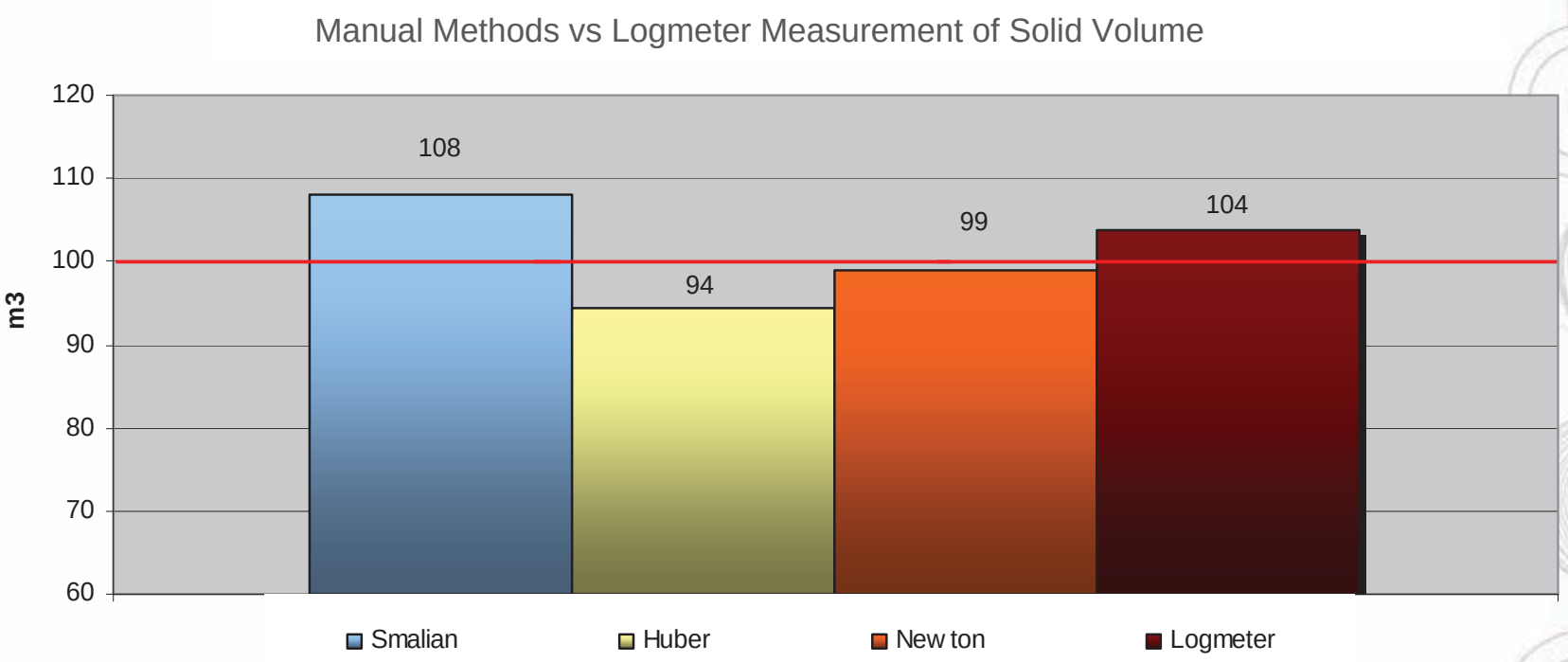
All individual piece scaling is based on **approximations**

- Log assimilated to solid of revolution
- Measures (diameter and length) are rounded

- Many methods (Smalian, Huber, Newton, etc…)

  → Dispersion of results

Comparing methods



15% difference between the most-used manual methods.

Study performed in the ARAUCO Nueva Aldea Mill, Chile in September 2007

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Comparing methods → Solid Volume

Indirect Methods with Sampling

1. Sampling Systems
2. Frame Volume
   - + Conversion Factor
   - + Piece Scaling
3. Weight Scales
   - + Piece Scaling
   - + Immersion systems

Direct Measurement Methods

1. Drive-Through Scanners

Comparing methods

Weight Scale + Piece Scaling

- Weight relates poorly to volume
- Risk of problems whenever context changes (Moutain Pine Beetle, etc)
- Easy to manipulate, perverse incentives
- Piece scaling is expensive
- Piece scaling has its own limitations (see section)

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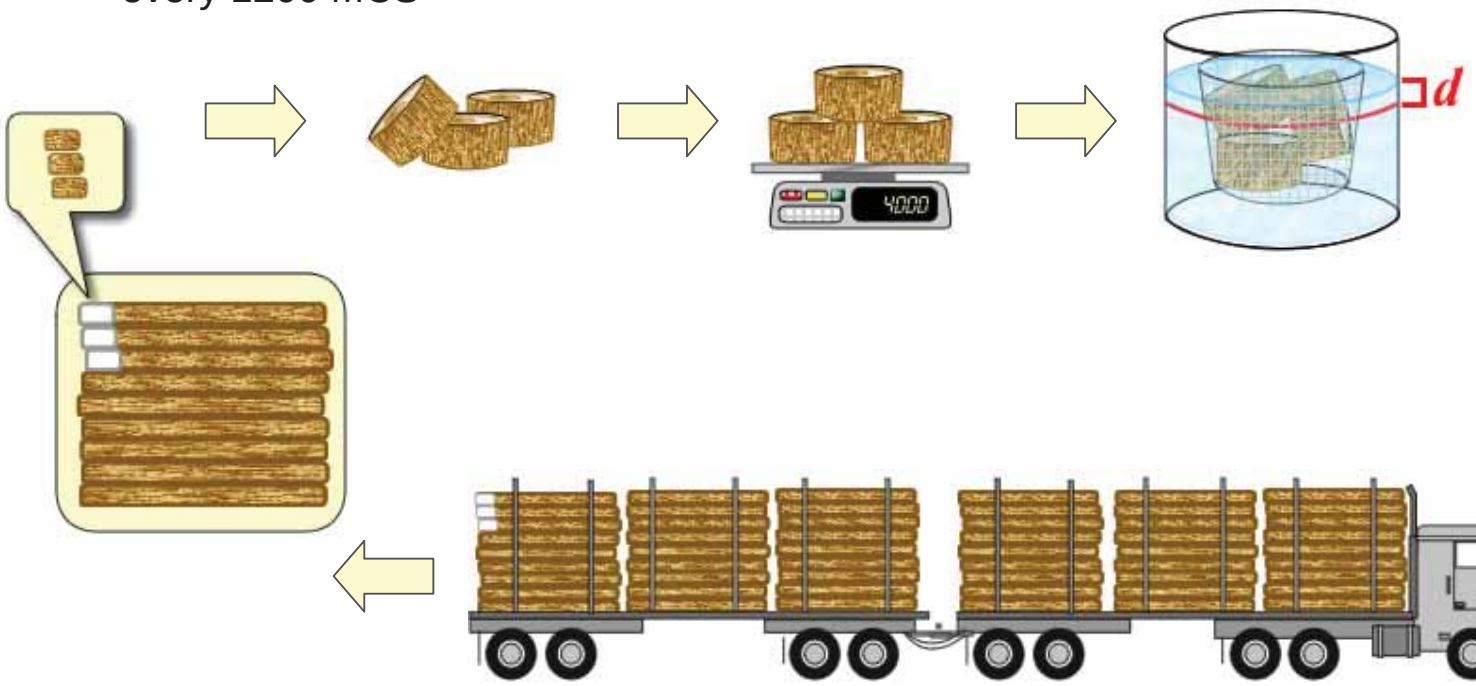
INDIRECT METHODS

Solid Volume from Weight : Conversion Factor

XILÓMETRO Laboratory

- Volume calculated through water displacement
- Calculated from samples less than 0.1% of the wood received (30 pieces – 30 cm) every 1200 MCS



The volume of the immersed samples equals the volume of the displaced water

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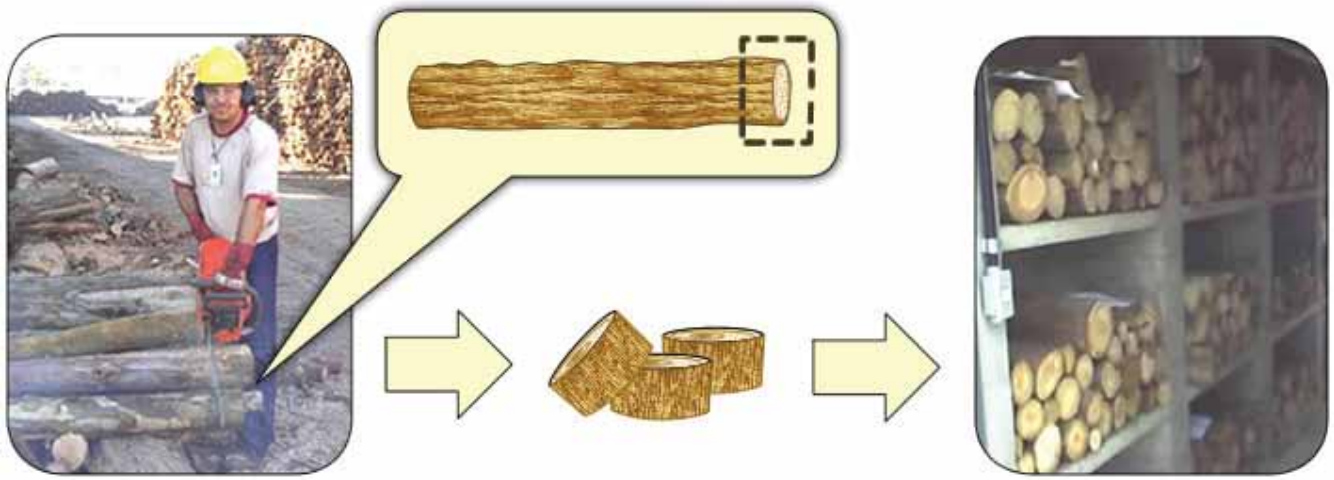
INDIRECT METHODS

Weight to Solid Volume: conversion factor calculation

XILÓMETRO Laboratory

- Samples comes only from the ends of the logs ➔ **NOT** representative
- Sample storage – administrative process ➔ doubts about the origin
- Non-auditable process – Risk of fraud



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INDIRECT METHODS

Weight from solid volume: conversion factor

INMERSION

- Uses the Archimedes principle – Perfect Method?
- Crane on a scale, or weight-measuring cell on the crane
- The sample is weighed out of and in the water
- Weight difference → volume displaced = VS




P1 = Crane + Claw + Wood

P2 = Crane + Claw + Wood – Weight of displaced water

INDIRECT METHODS

Weaknesses in practical evaluation of solid volume

- **IMPRECISION OF THE MEASUREMENT**
  - Variation in the inmersion of the claw
  - Dynamic forces in and out of the water
  - Water with floating
  - Sample always fron
  - Calculates small differences between large numbers
- **Complex operation**
  - Slow
  - High operational costs
  - Non-auditable process

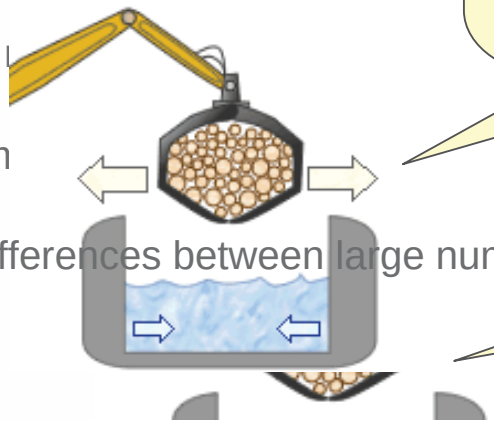
The movement of the claw in and out of the water generates dynamics forces that distort the measurement

claw

fects

e

Floating pieces of wood alter the measured volume



Comparing methods → Solid Volume

Indirect Methods with Sampling

1. Sampling Systems
2. Frame Volume
   - + Conversion Factor
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3. Weight Scales
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   - + Immersion systems

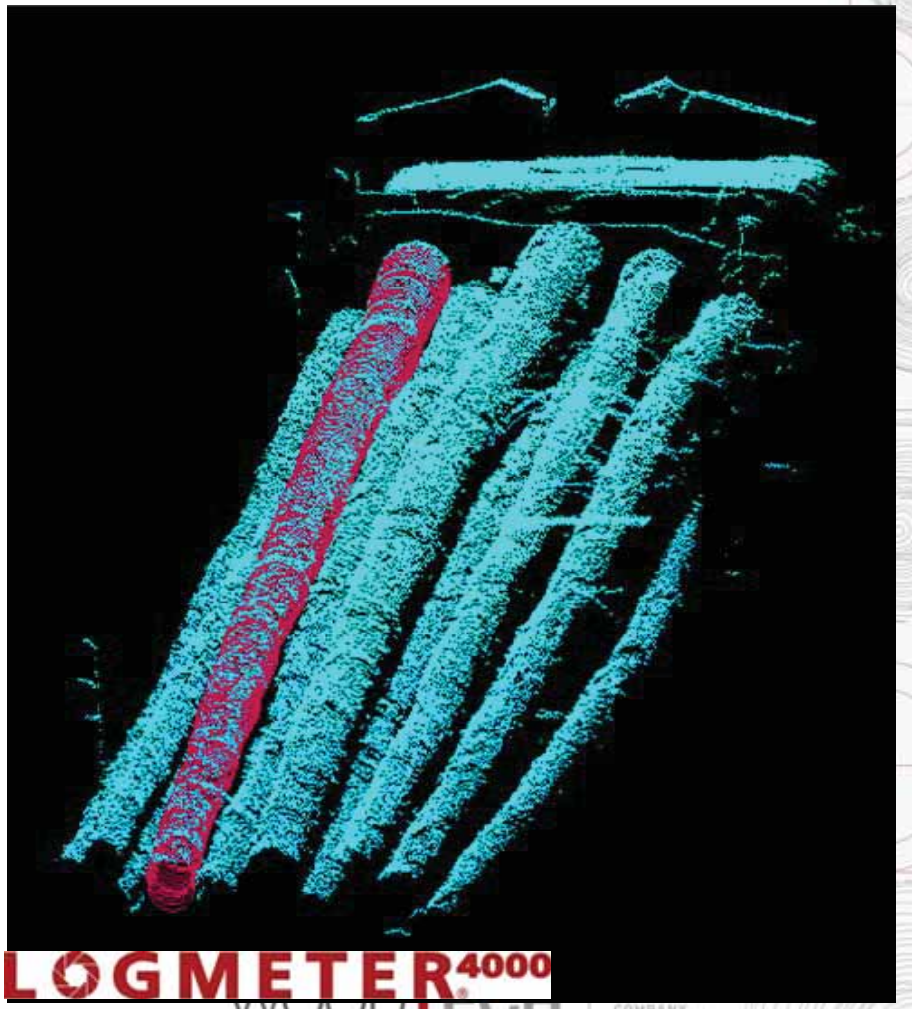
Direct Measurement Methods

1. Drive-Through Scanners

Comparing methods

Drive Through Scanners

- Solid Volume and Frame Volume
- Biometric Characteristics
- 100% Auditable
- 100% Objective
- Low running costs



The only non-sample system for SOLID volume

Will be detailed more in next presentation

Conclusion

- WOOD measurement is VALUE measurement
- The only unit consistently related to Value is SOLID VOLUME
- Sampling systems have been used a lot but have many limitations
- No system is perfect
- Whole load scanners are being adopted by the pulp industry…
  …soon by the lumber industry too?

Correctly quantify wood is important

...But far from simple

There is no perfect method

…But there are advancements.

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THANK YOU!

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