Creating improved product quality through understanding of fiber genetics and environmental impacts

8th Pira International Conference – Fibre Engineering – The Impact Forum
Barcelona 2005

Ergilio Claudio-da-Silva Jr.; Braz Demuner and Gabriel Rezende - Aracruz Celulose S.A.

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AGENDA

- Fiber Development at Aracruz
  - Impact of genotypes on fiber quality
  - Impact of environmental on productivity
- Introduction – What's Aracruz
  - Impact of enviroments x genotypes on fiber quality
- Value creation at Aracruz
  - The Fiber Plataform Concept
- Final Remarks


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MARKET PULP BUSINESS
CRITICAL ASPECTS
- Sustainability
- Capital Intensiveness
- Extremely Competitive

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WHAT'S ARACRUZ ?

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ARACRUZ IN BRIEF

- A Brazilian forest products company based on sustainable tree plantations
- Integrated operations: forests-mill-port
- World leader in the eucalyptus pulp market – 2.4 MM t/ y
- Plantations in 4 Brazilian states
- Pulp mills in Espírito Santo and Rio Grande do Sul
- High tech sawmill for lumber production in southern Bahia (Lyptus)

➢ Market - global producers of *high value-added* consumer products

➢ Worldwide sales – offices in Miami (USA), Nyon (Switzerland), Hong Kong and Beijing (China)

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Units and offices in Brazil

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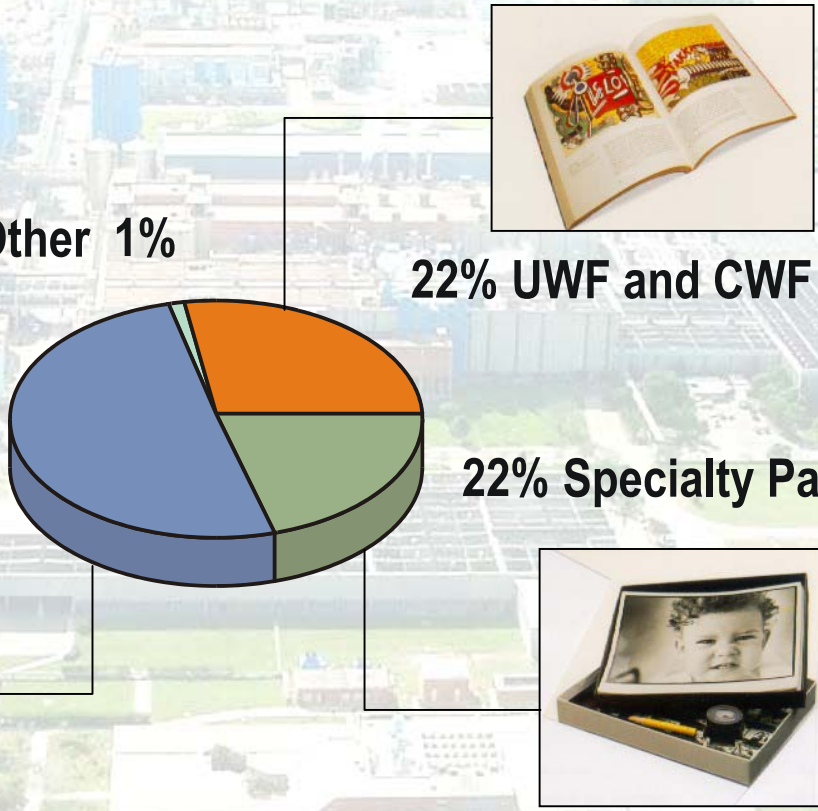
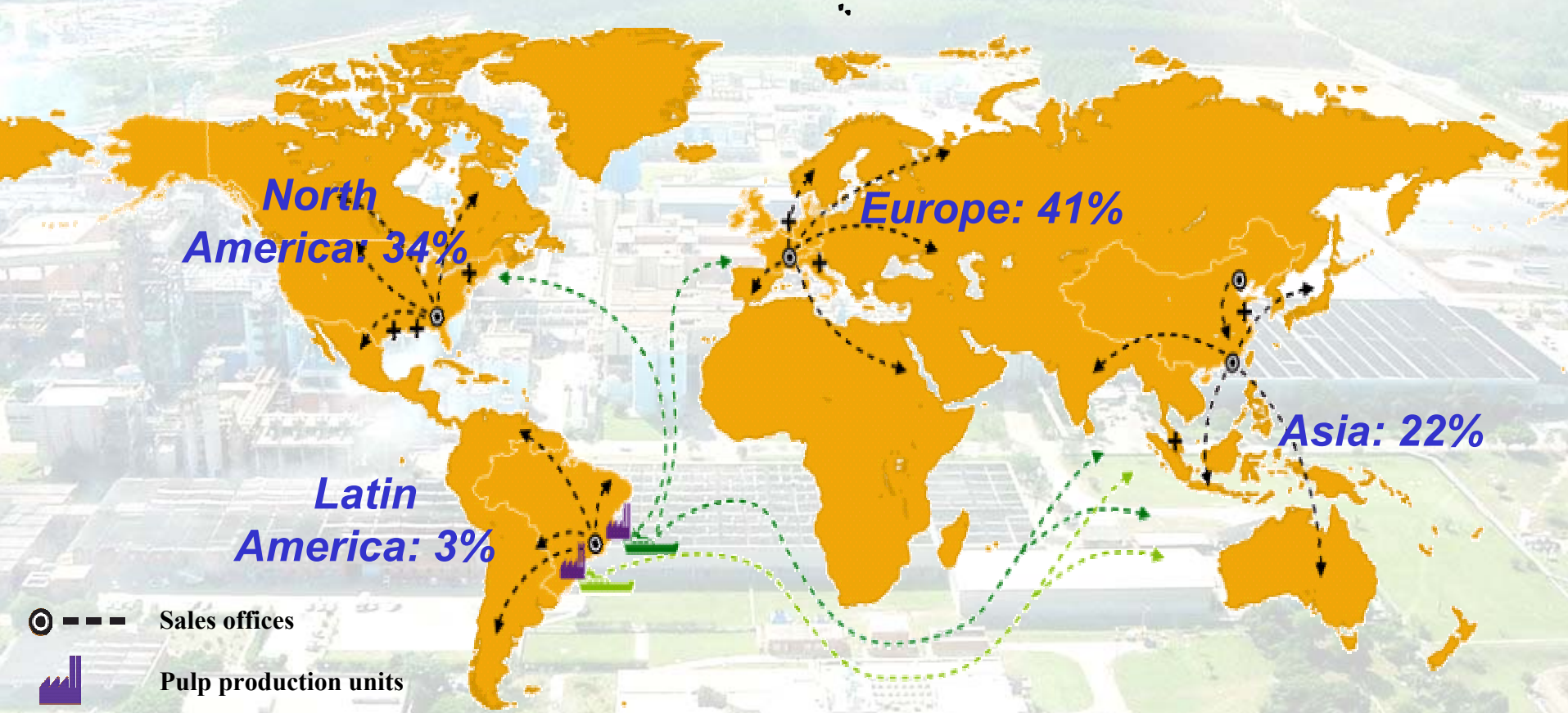
Aracruz Market by End uses - 2004

Types of Paper



Aracruz' 2004 - Sales by Region

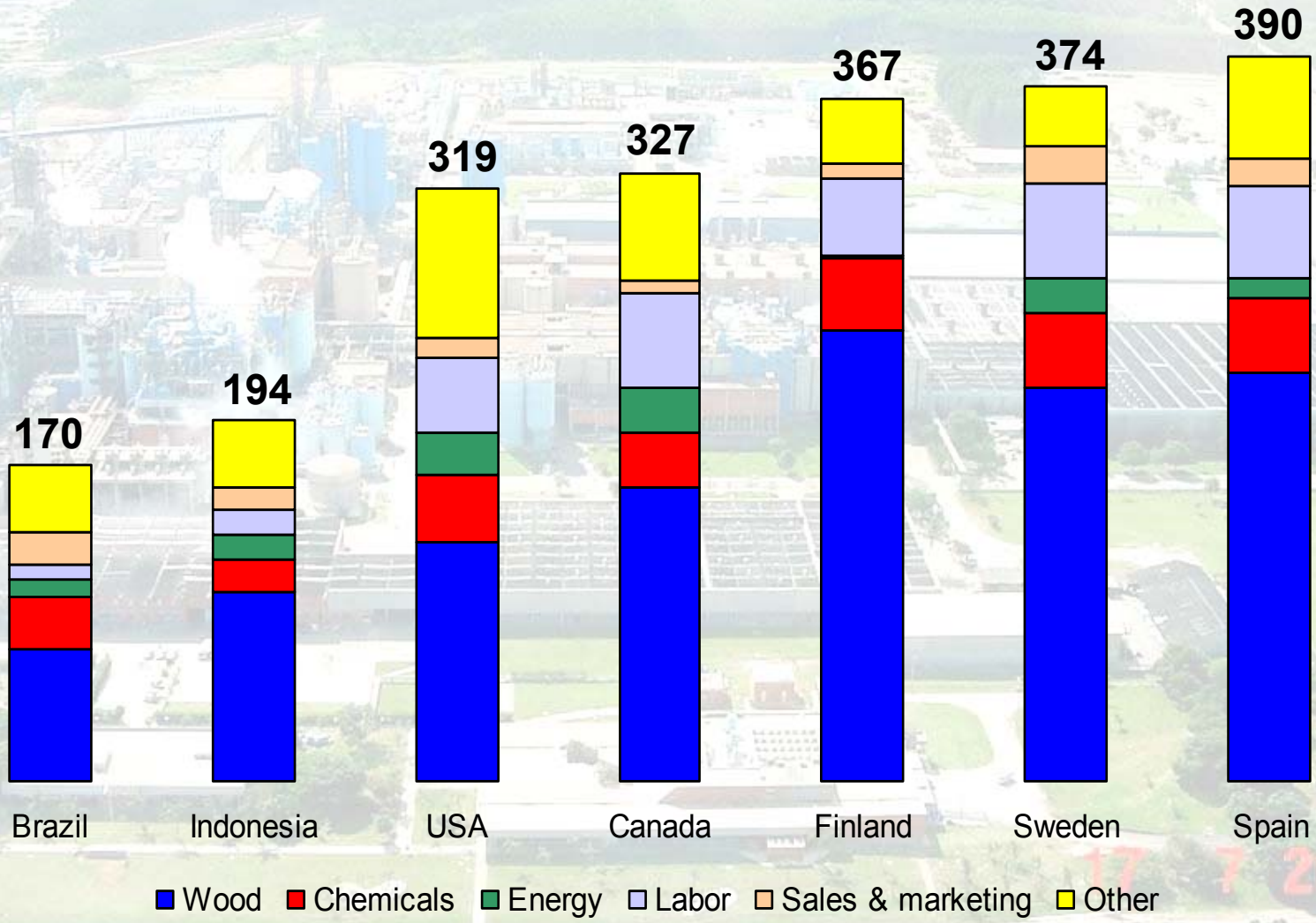
98% of revenues and 40% of cash costs are USD-linked



Pulp Sales Volume = 2.449.752 tons

Sustainable Cost Leadership

HW Cash Production Cost 2Q04



Sources: HW

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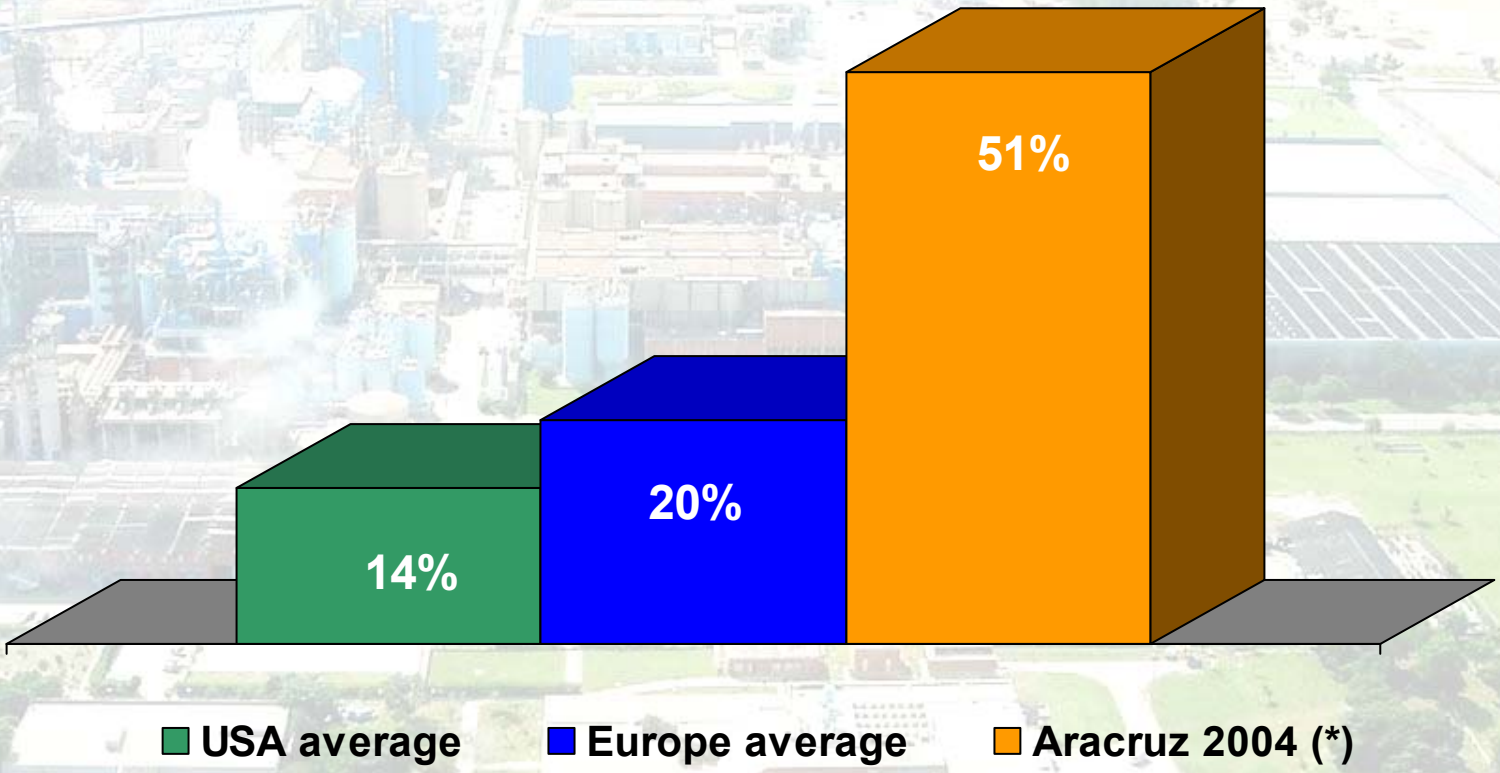
Highest EBITDA Margin of the Industry



(*) Adjusted by other non-cash items

Source: Companies' reports and Bloomberg

Fully Integrated Operations

Forests

Mills

Logistics

Integrated Eucalyptus Plantation

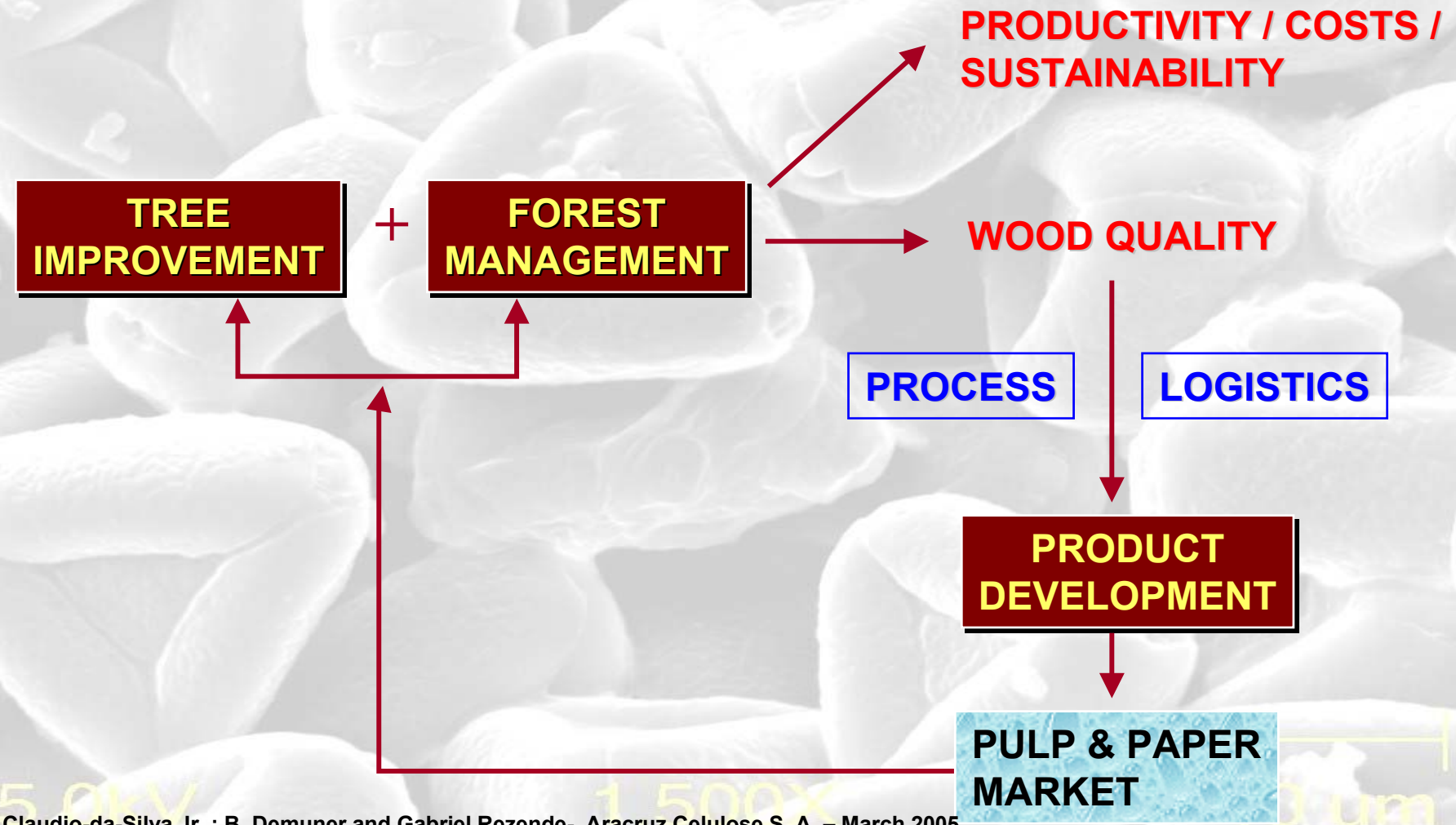
INTEGRATED WITH NATIVE, REMAINING OR REPLANTED FORESTS - Adequate Biodiversity

- ***Two hectares of eucalyptus to one of preserved area.***

AGENDA

- Introducation – What's Aracruz
- **Fiber Development at Aracruz**
  - **Impact of genotypes on fibre quality**
  - **Impact of environmental on productivity**
  - **Impact of enviroments x genotypes on fibre quality**
- Value creation at Aracruz
  - The Fiber Plataform Concept
- Final Remarks

Aracruz Innovation Strategy:
Integrated Value Creation through Fiber and Process Management



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Fiber Development at Aracruz

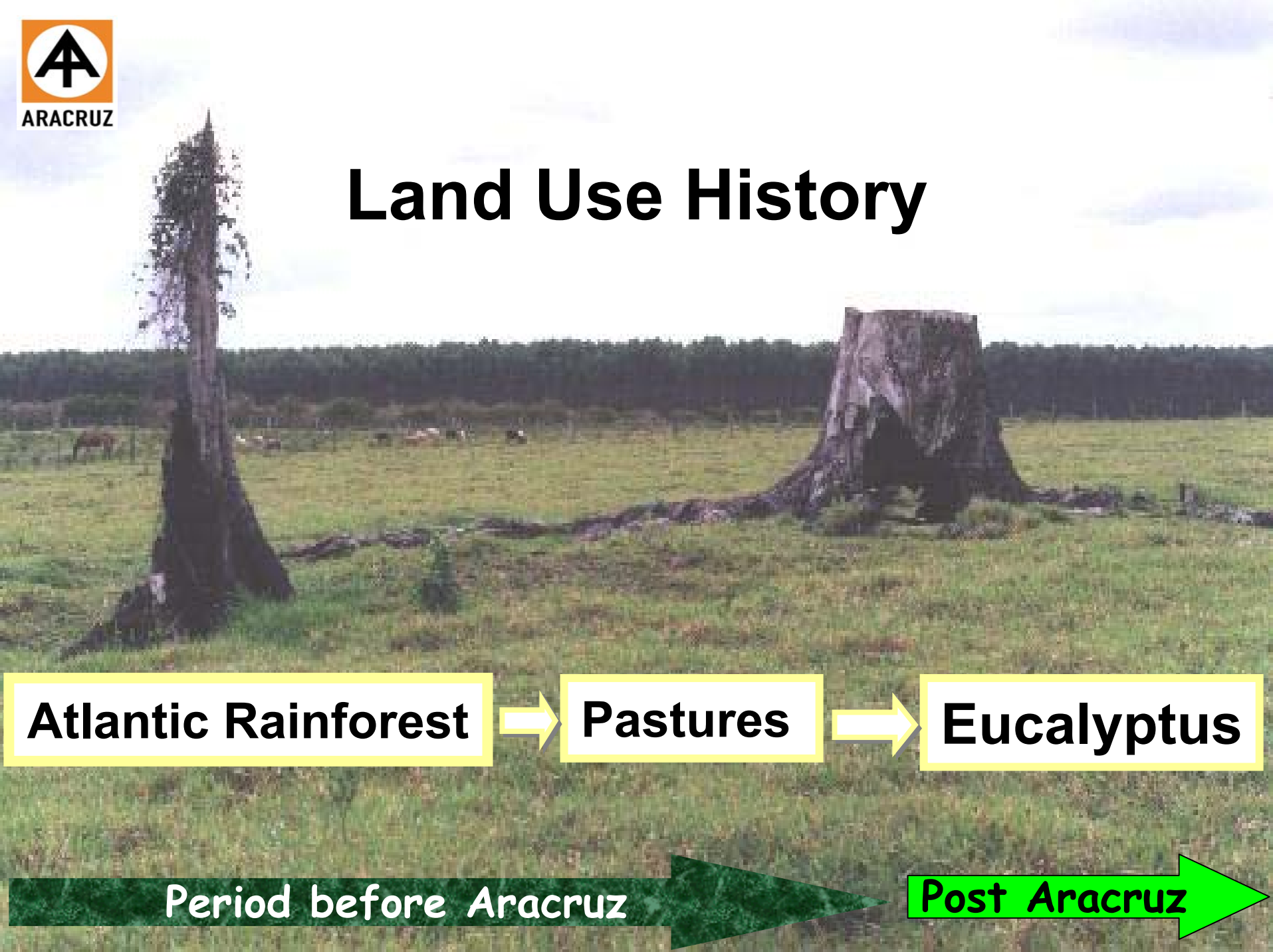
- **70's:** adaptability
- **80's:** productivity (m^3/ha)
  starting fiber quality evaluation
- **90's:** productivity (adt/ha)
  fiber quality understanding
- **00's:** the "fiber platform" concept

70's: adaptability:

- Commercial plantations: *E. grandis* and *E. saligna*
  - Medianly to strongly attacked by "canker disease."
- R&T: introduction of 55 Eucalyptus species from Australia and Indonesia.
  - E. grandis (Australia), E. urophylla (Indonesia) and its hybrids:
    - ⇨ higher potential – adaptability, productivity and quality (pulp yield).

30 m3/ha.year ; 4.7m3/adt.

Land Use History



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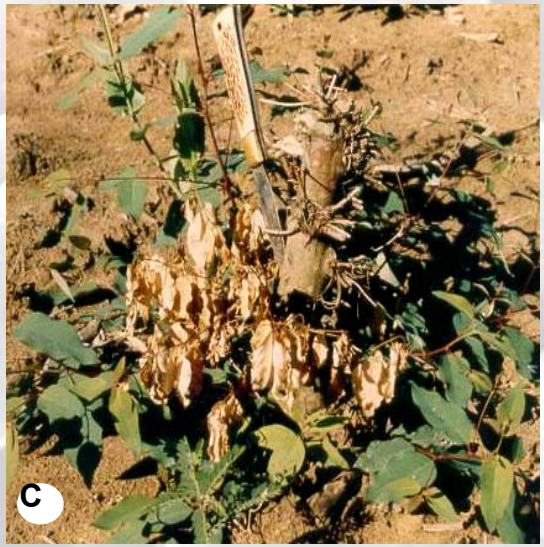

Details of "Canker" disease

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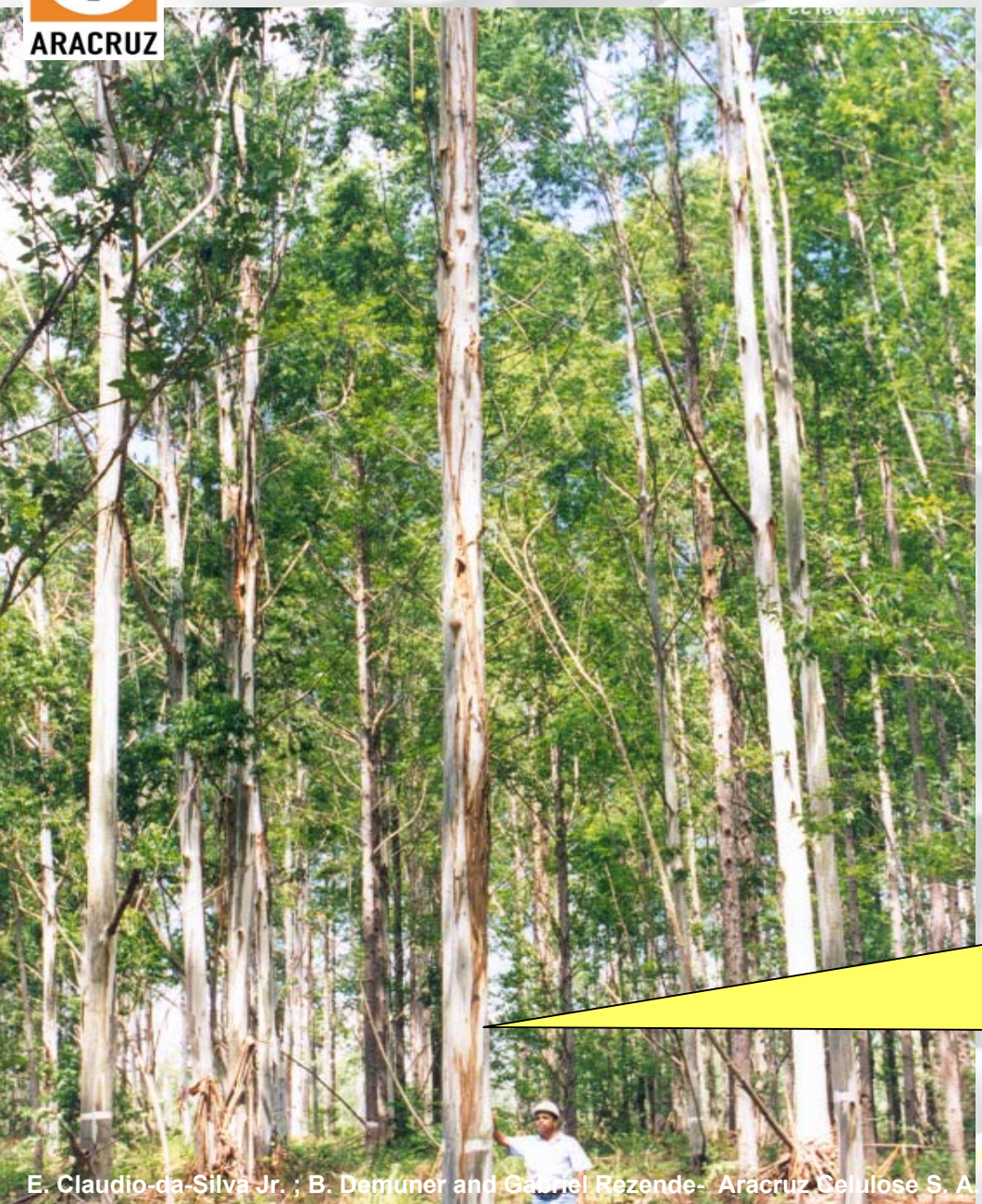

Aracruz made one of the broadest introductions of *Eucalyptus* genetic material in the world, from Australia , South Africa and Indonesia.

"Mother - tree", *E. grandis*, Atherton / Australia: source of our first *Eucalyptus* families

80's: productivity - starting fiber quality evaluation

- New genetic material introductions.
- Own improved seed production of G x U hybrids.
- Vegetative propagation (clones) development
  - commercial use: 90% of seedling production in 1986.
- Start up of genotypes x environments studies.
- Start up of “Fiber Quality Tree Selection Program".
- Pioneering commercial pulp production from a clonal forest.

35 - 40 m3/ha.year ; 4.3 m3/adt.

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Aracruz: pioneer in the use of clonal propagation in commercial scale.

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3 months

1 year

3 years

80's – Significant productivity and uniformity of the Planted Forests !

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Clonal forest (24 months):
higher productivity / uniformity

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6 years old

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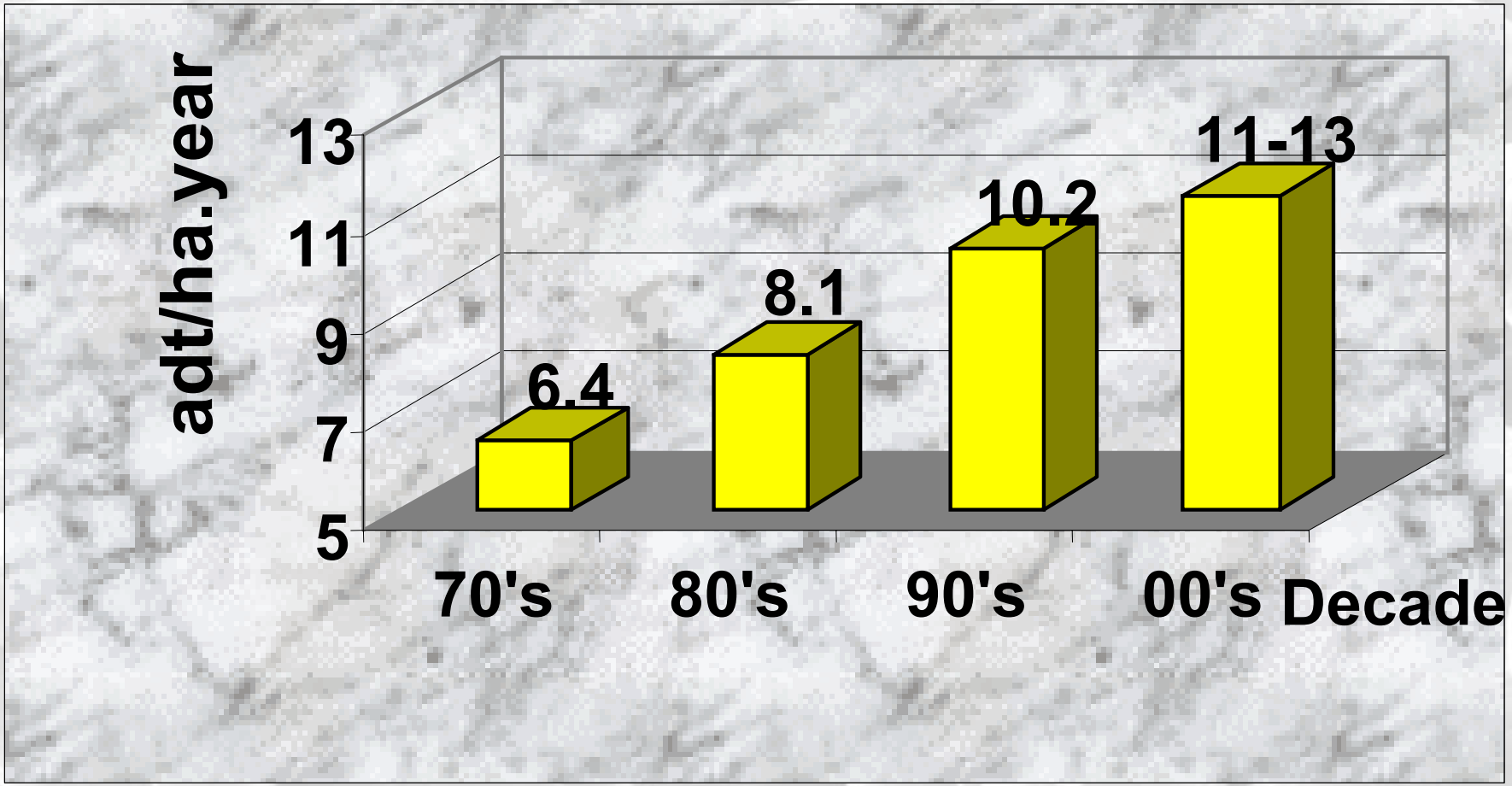
Added Value



90's: productivity (adt/ha), fiber quality understanding

- **Early selection and flowering induction** → high impact on genetic gain
- **Selection index application (strategical decision)**
- **Non destructive wood evaluation: NIRS, Pylodin**
- **Genotypes x fiber quality studies**
- **Environments x productivity x fiber quality studies**

40 – 45m3/ha.year ; 3.8m3/adt

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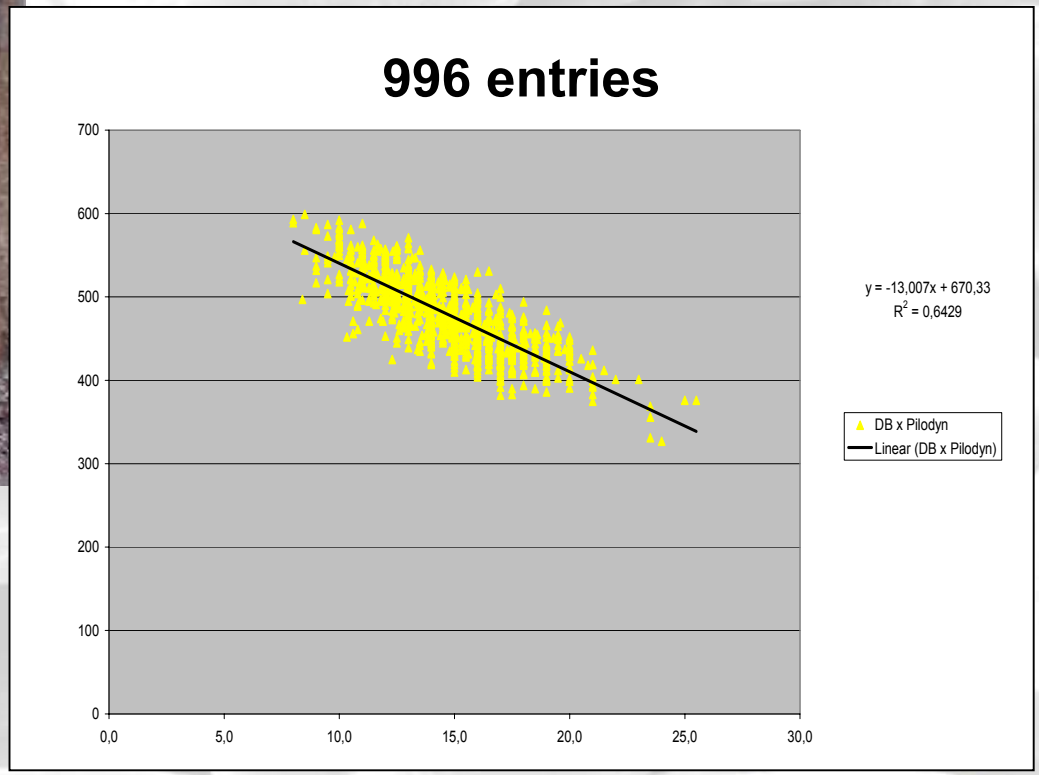
Own production of improved hybrids:

- Flowering induction
- Controlled pollination in "greenhouse"

NON DESTRUCTIVE WOOD QUALITY EVALUATION

Pylodin



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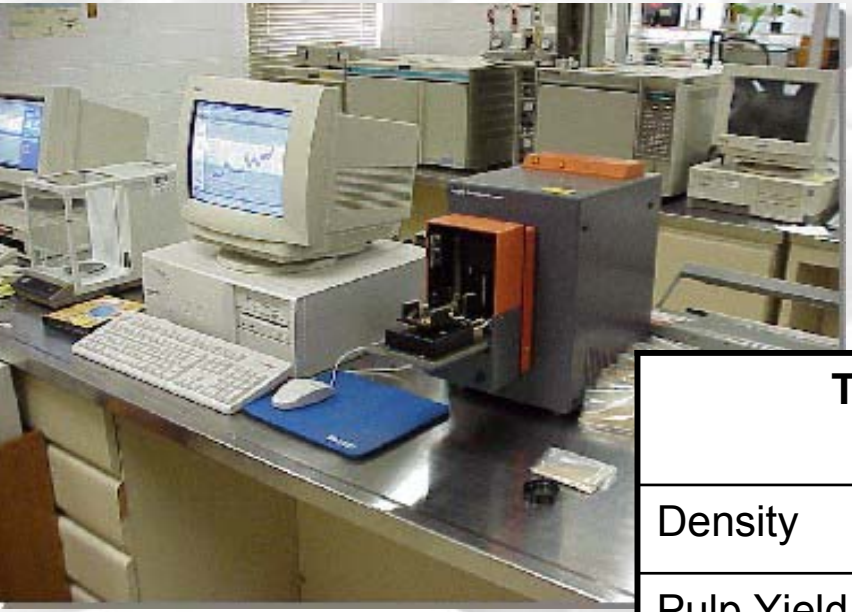
NON DESTRUCTIVE WOOD QUALITY EVALUATION



NIRS

Trait	R^2	Standard Error	Number of Factors
Density	0,82	25,84	6
Pulp Yield	0,66	0,86	5
Specific Consumption	0,67	0,27	4
Lignin Content	0,80	0,73	3
Pentosans Content	0,80	0,68	4
No. Fibers / g	0,81	1,76	6

Rezende et all, 2001

90's: productivity and fiber quality understanding

- Impacts of genotypes x fibre quality
- Environments x productivity x fiber quality

FIBER QUALITY X CLONES X ENVIRONMENTS:

What have we learned???

Earlier publications:

Source: Demuner & Claudio-da-Silva - Paper Physics Conference -1991

Simple regression model for different species and hybrids of eucalyptus :

- wood basic density
- Nº of fibres per gram
- pentosans content

} Explain up to 80% of selected paper properties

•Very simple to measure, and possible to control

Earlier publications:

Source: 1991– Demuner & Claudio-da-Silva - Paper Physics Conference: (cont.):

Hypotheses developed in 1991:

"Wood density:

- *high degree of heritability*
- *can be controlled within defined limits.*
- *fiber flexibility can be defined in the forest*

Nº of fibres per gram:

- *Also prone for control via silvicultural practices.*

Pentosans content:

- *control also might start in the forest.*
- *not yet clear whether this property can be easily manipulated via genetic engineering or silvicultural."*

Earlier publications:

Source: 1992 – Bertolucci & Demuner - Tecnicelpa – Portugal and Tree Breeding - New approach – São Paulo - Brazil

Heritability and genetic vs. environmental interactions:

"Heritability":

- Wood basic density = 90%;
- Number of fibers per gram = 74%; and
- Wood pentosans content= 95%

HOWEVER …

Genetic x Environmental interactions for 27 characteristics:

- Significant interactions were predominantly complex for 11 of the 27 different characteristics evaluated.
- A wide range of variation was observed"

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"Suddently we had a new degree of practical complexity for the genetic selection and improvement."

And, as the forest was being developed, a new scenario became evident :

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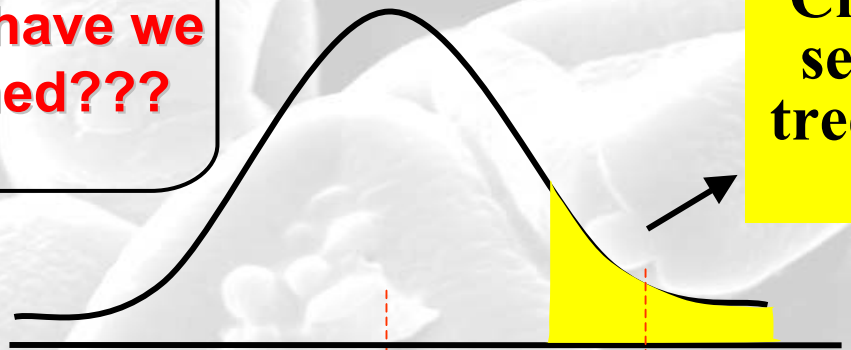
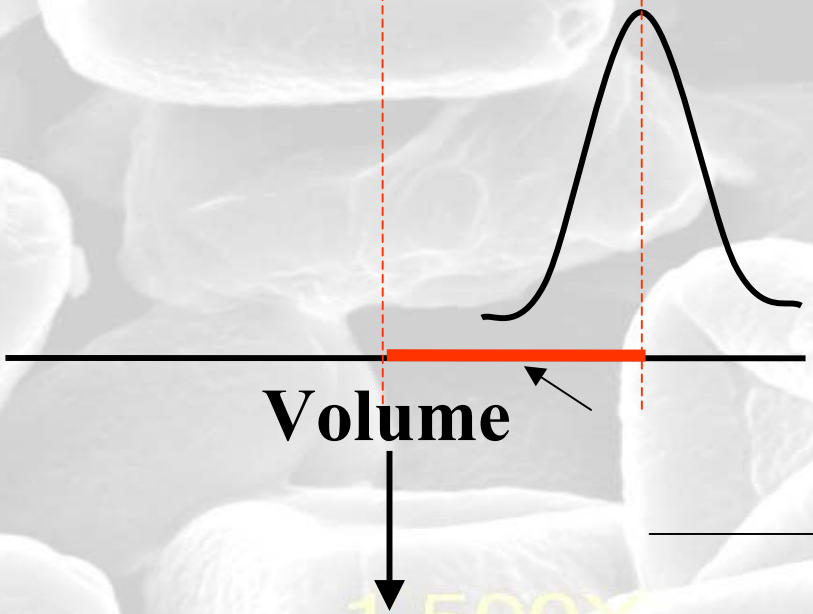
1) FIBRE QUALITY X GENOTYPES:

What have we learned???



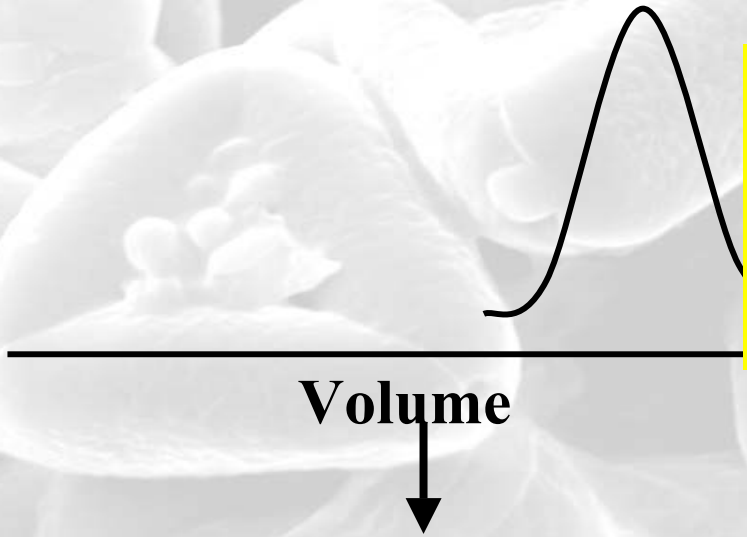
Clonal propagation: selection of the best trees based mainly on volume.



Result: expressive gain in productivity and uniformity (FOR VOLUME).

1) FIBER QUALITY X GENOTYPES:

As volume x fibre quality attributes are not highly correlated (genetically speaking) ...



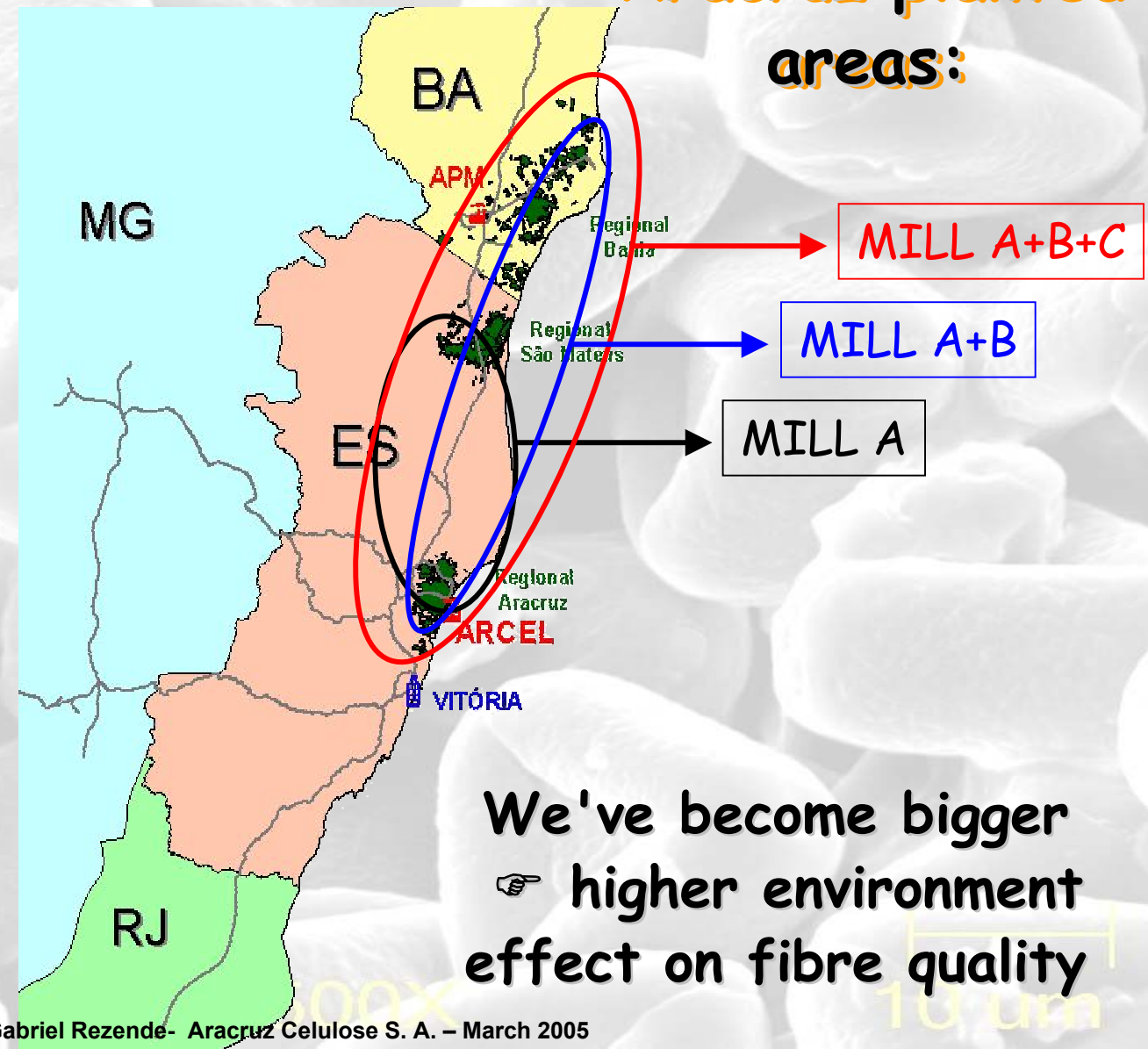
...at the bottom line we planted outstanding clones in volume and yield...

...but with normal variation for some important fibre quality traits.

Wood density, hemicellulose, lignin, morphology, etc.

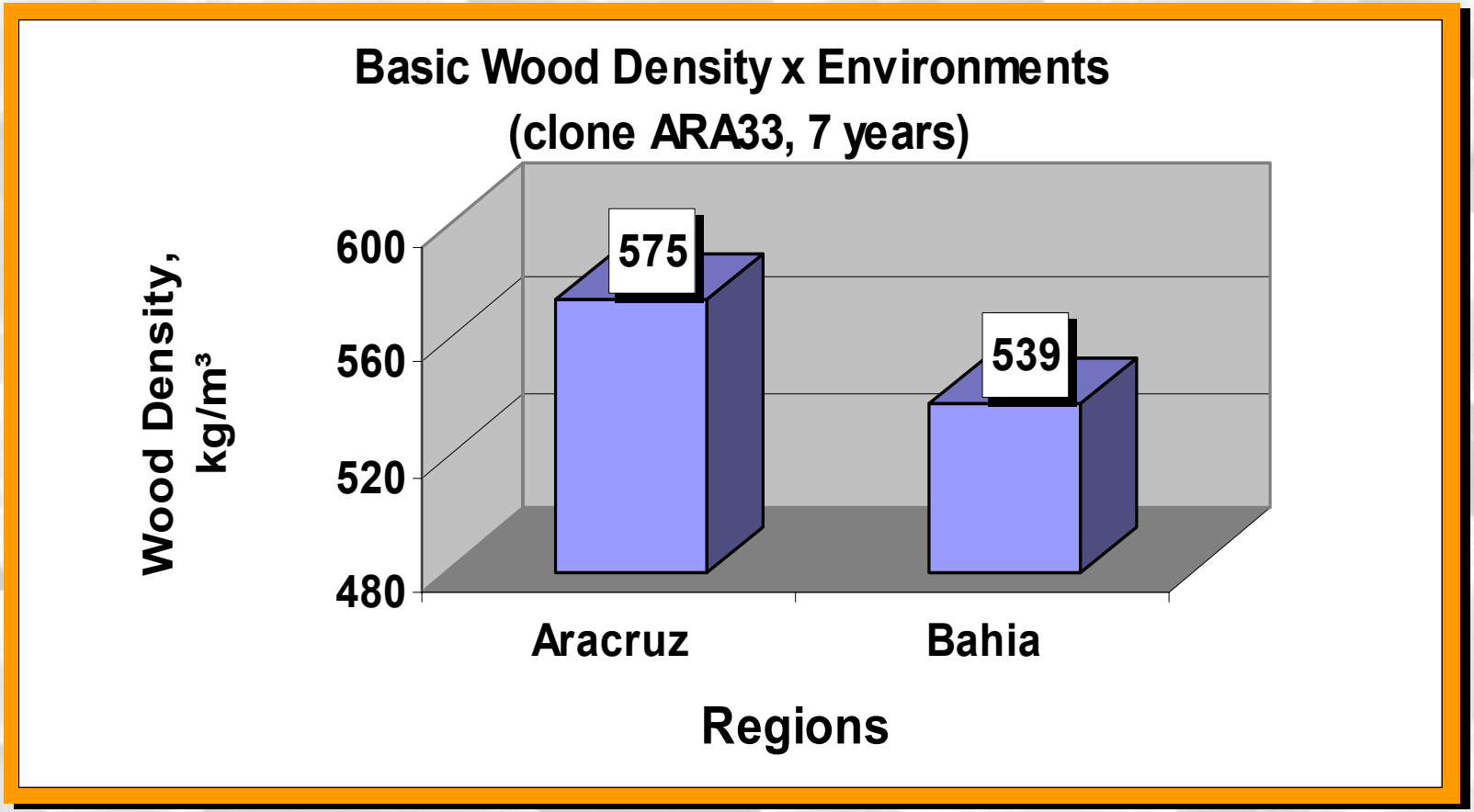
2) FIBER QUALITY X ENVIRONMENTS:

Aracruz planted areas:



We've become bigger ☞ higher environment effect on fibre quality

2) FIBER QUALITY X ENVIRONMENTS:



The effect of the environment on the wood density is significant

1) FIBRE QUALITY X GENOTYPES:

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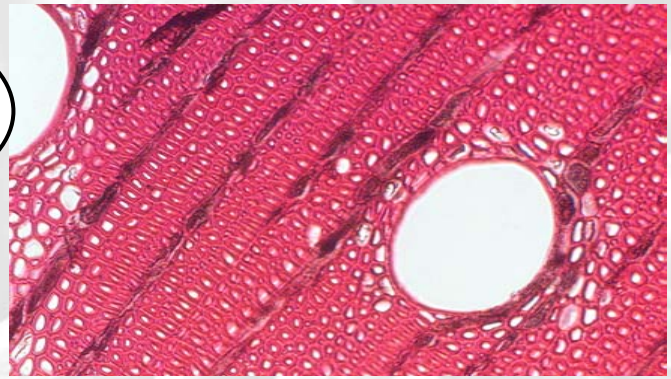
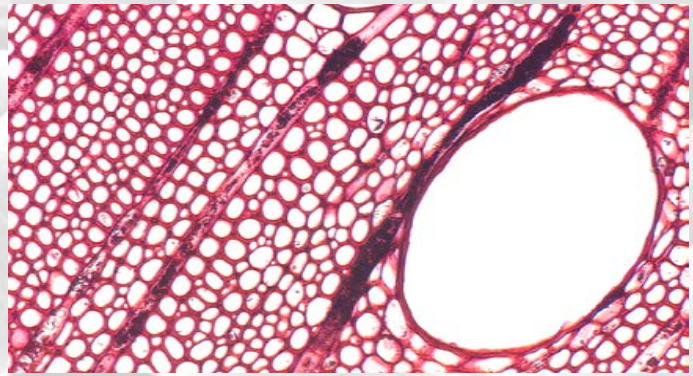
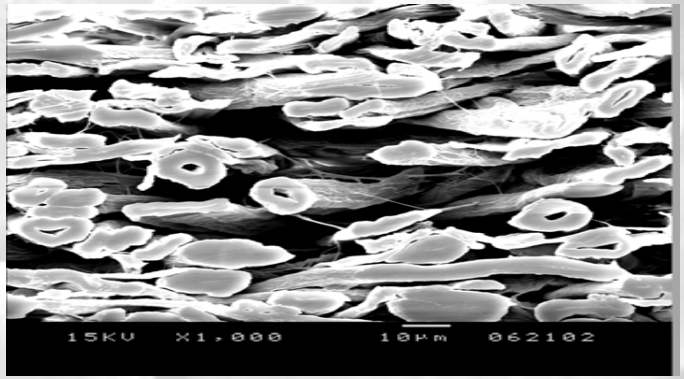
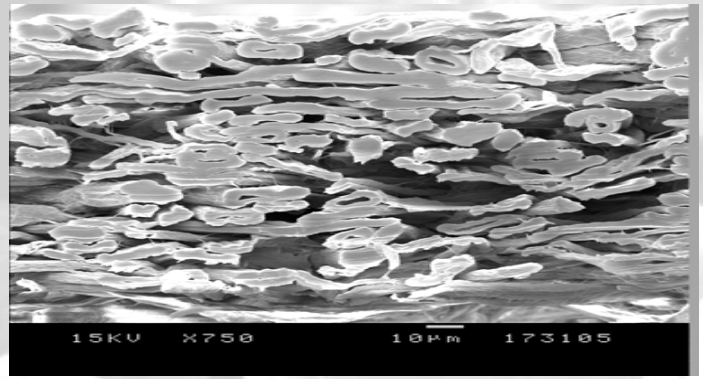
Clone A – Higher Wood Density

Clone B – Lower Wood Density









Examples like this one can be expected, since there is a significant interaction between environments x productivity x fibre quality.

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FIBER QUALITY X CLONES X ENVIRONMENTS:

In summary: outstanding but somewhat different clones, planted in diverse environments = important variation in fiber quality !

FIBER QUALITY X CLONES X ENVIRONMENTS:

… and the outstanding uniformity ,obtained via large scale clonal forestry, should be very efficiently managed, in the forest and in the mills.

Summarizing accumulated knowledge:

Forestry productivity:

- ✓ increasing continuously
  - ✓implementation of new genetic materials; and
  - ✓sustainable management practices

Wood Density:

- ✓ impacts on the economics
- ✓ Impacts on paper properties
- ✓ Strict control within limits had been defined

fibre morphology:

- ✓ key attributes for P&W and tissue papers
- ✓ more affected by age than environment
- ✓ marginal gains in the balance morphology x density could be achieved with shorter rotations.

Pulp pentosans

- ✓ key attribute for inter fibre bonding.
- ✓ ca n be modified by harvesting age (not necessarily economical) and process technologies.

So, how did the development work proceed ?

Clear indication in the early 00's:
NEAR-TERM DEMANDS UPON PAPER GRADES

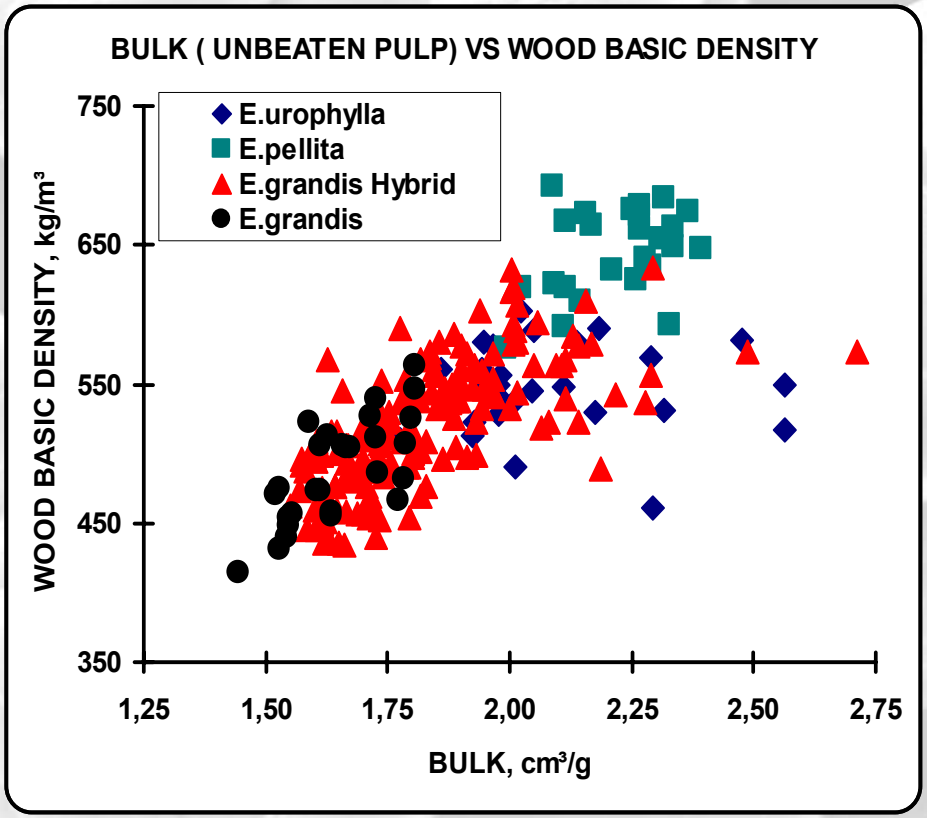
Property	Near - term Demand
High brightness	91+ minimum
Surface for printing	Smoothest and strong surface adhesion
Formation / topography / pore structure	Fiber density variation is key
Paper visco- ellastic properties (incl. compressibility)	Bulk / stiffness are key
Wettability / dimensional stability / absorbency	All controlled

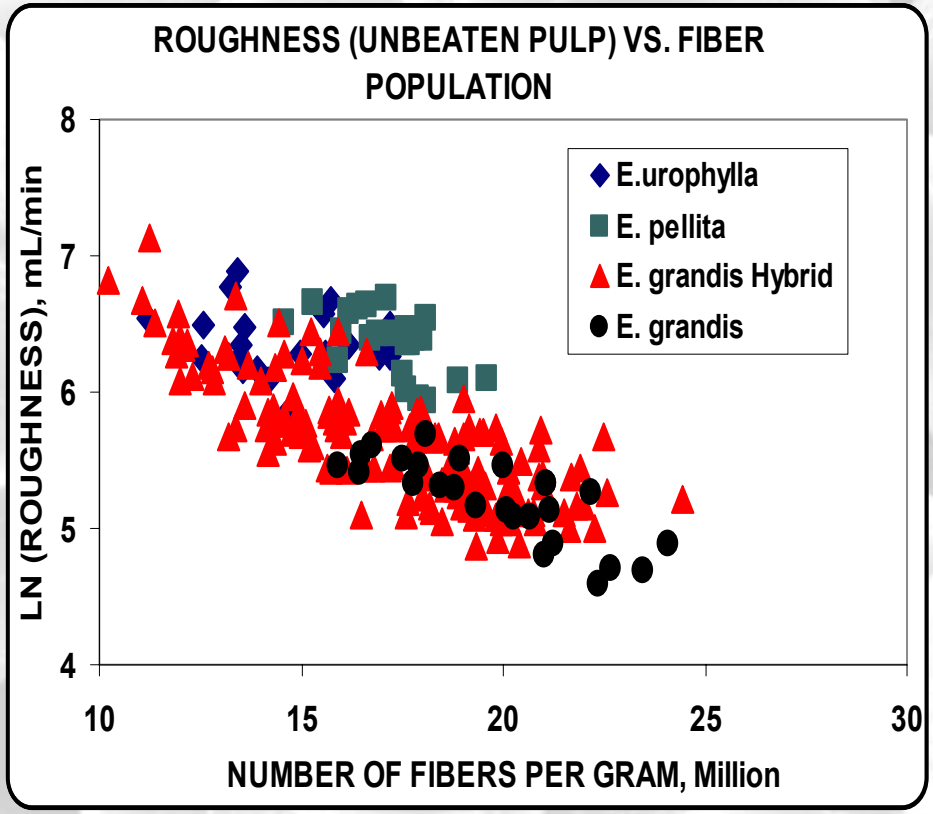
...AND THE DEMANDS UPON PULP FIBERS:

Property	Demands
Fiber dimensions even more important	*uniformity a plus*
Low coarseness / large number of fibers per gram	*key*
Highest possible internal and surface strength -	Good drainage / good pore structure / absorption properties
Surface chemistry becoming more critical	bonding / electrical props / low water consumption mills
Proper interaction with pigments & fillers -	porosity / surface chemistry

… while the data from the field indicated :

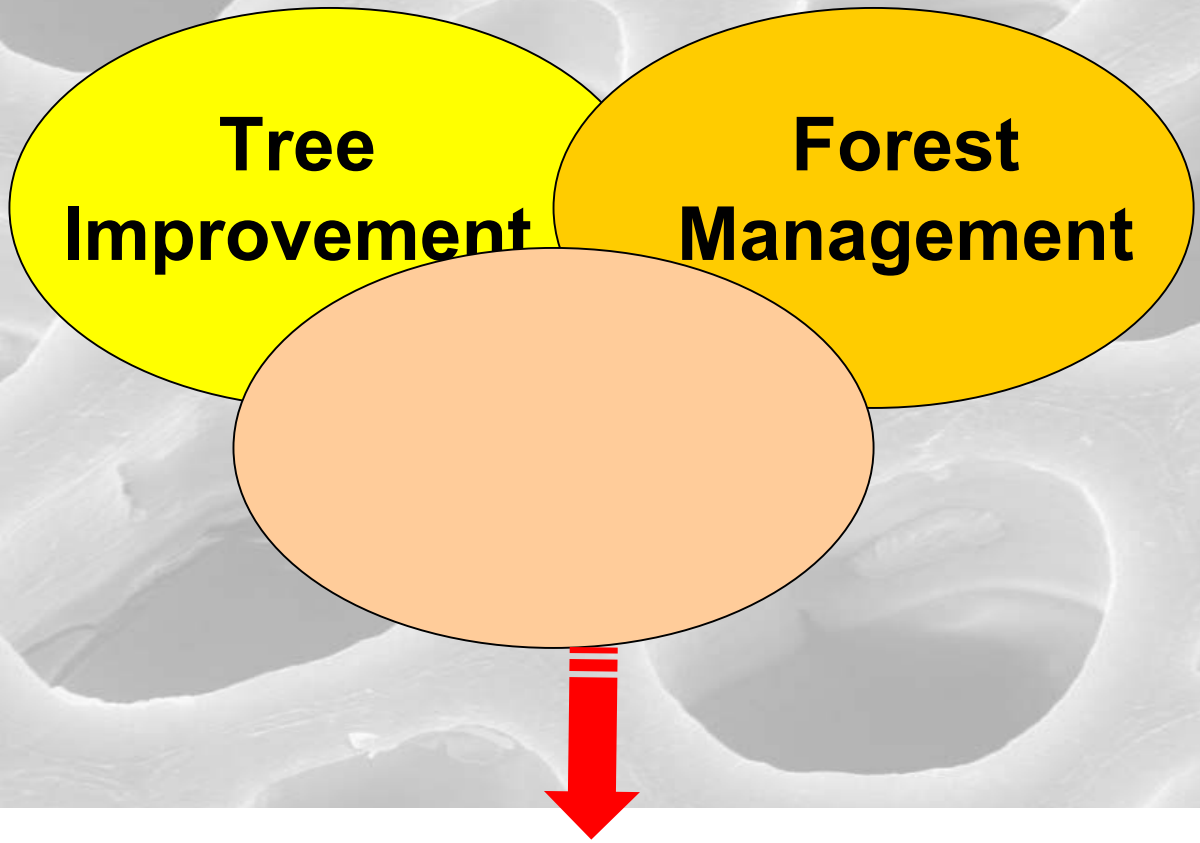
Wood characteristics are still key for most paper properties.





Even though some literature still not very conclusive about this.

Therefore, a new concept of fiber quality development was needed:



The Fiber Platform Concept

2000 – Bertolucci et all - Tappi Pulping Conference

Fiber Development at Aracruz

The "fiber platform" concept

Product Quality f **fiber quality at the mill gate**
mill process segmentation

15.0kV 2kX 5 um

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Fiber Development at Aracruz

The "fiber platform" concept

Product Quality f **fiber quality at the mill gate** + **mill process segmentation**

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"Fiber platform"- at forest/ logistics levels :

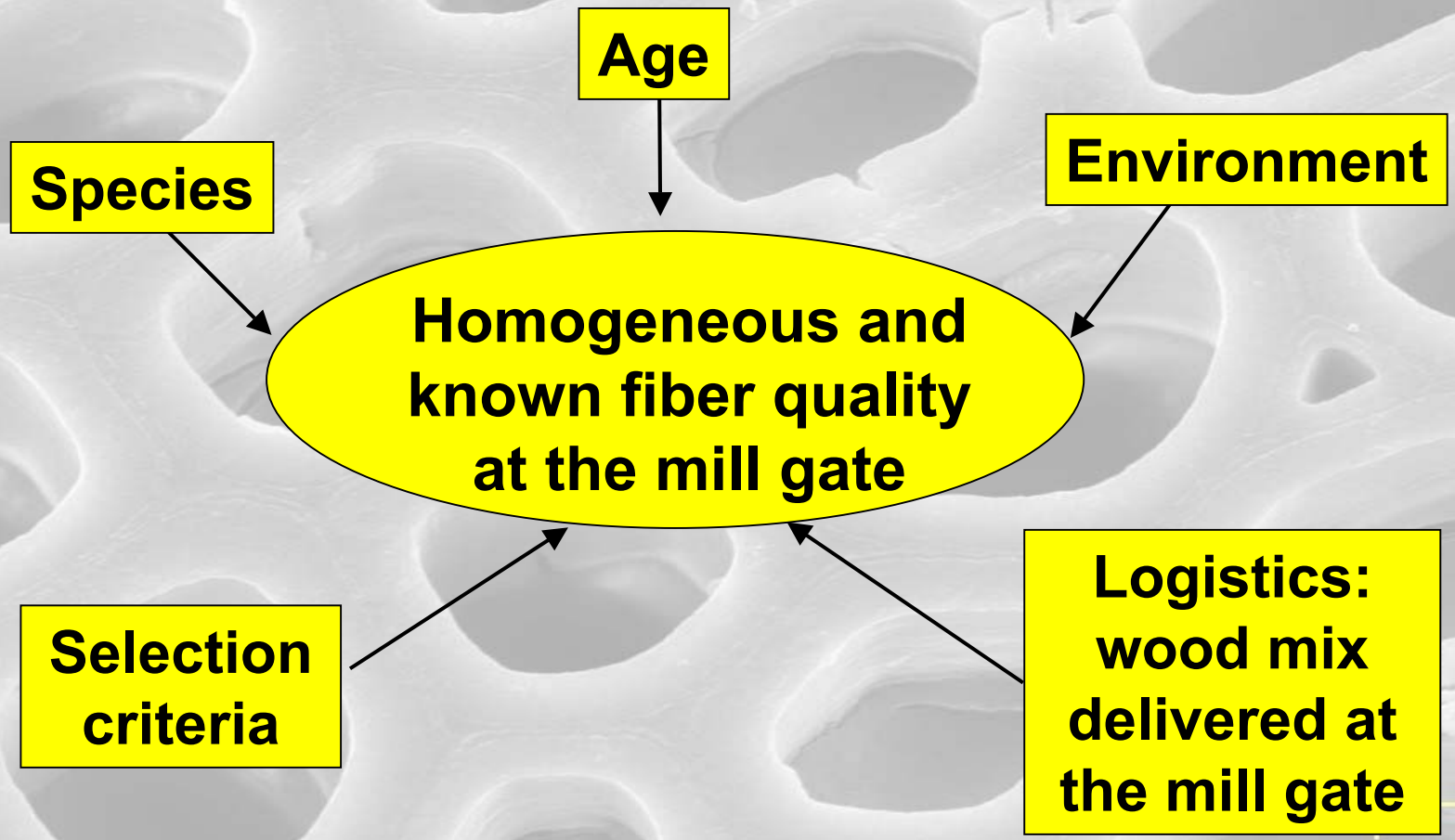
Homogeneous and known fiber quality at the mill gate:

- Result of fundamental knowledge of fiber quality attributes

+

- Complex management of a series of interrelated factors at the forest level.

"Fiber platform"- at forest/ logistics levels:



Fiber Development at Aracruz

The "fiber platform" concept

Product Quality f **fiber quality at the mill gate**
mill process segmentation

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The "fiber platform" concept

Mill process segmentation: e.g.pulping, bleaching and dry end.

Compact Cooking (fibreline C)

Modified Cooking (fibreline B)

New pulping (fibreline A)

Lo-Solids Cooking (fibreline Guaiba)

Modern Bleach.Sequence (fibreline C)

Master Invest. Plan (fibrelines A and B)

Wet end chemistry applicat. (5 fibrelines)

Additives

etc…

Present Results

Some results already obtained with the Fiber Platform implementation at Aracruz

15.0kV 2kX 5 um

Current Best Elite vs New Elite Clone
2.5 years old

15.0kV 2kX 5 um

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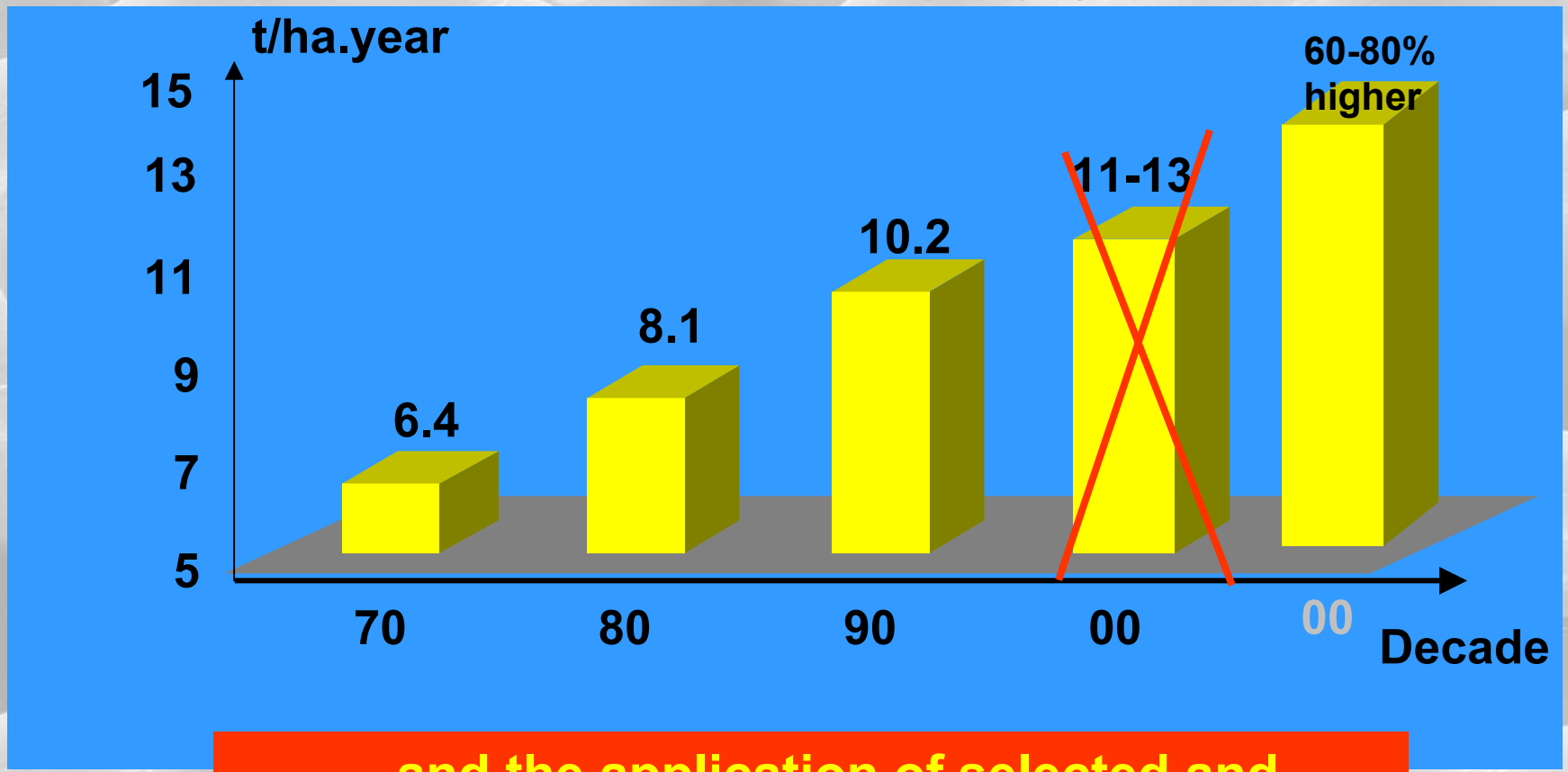
New Elite Clone
Current Elite Clone
1 year-9 months old

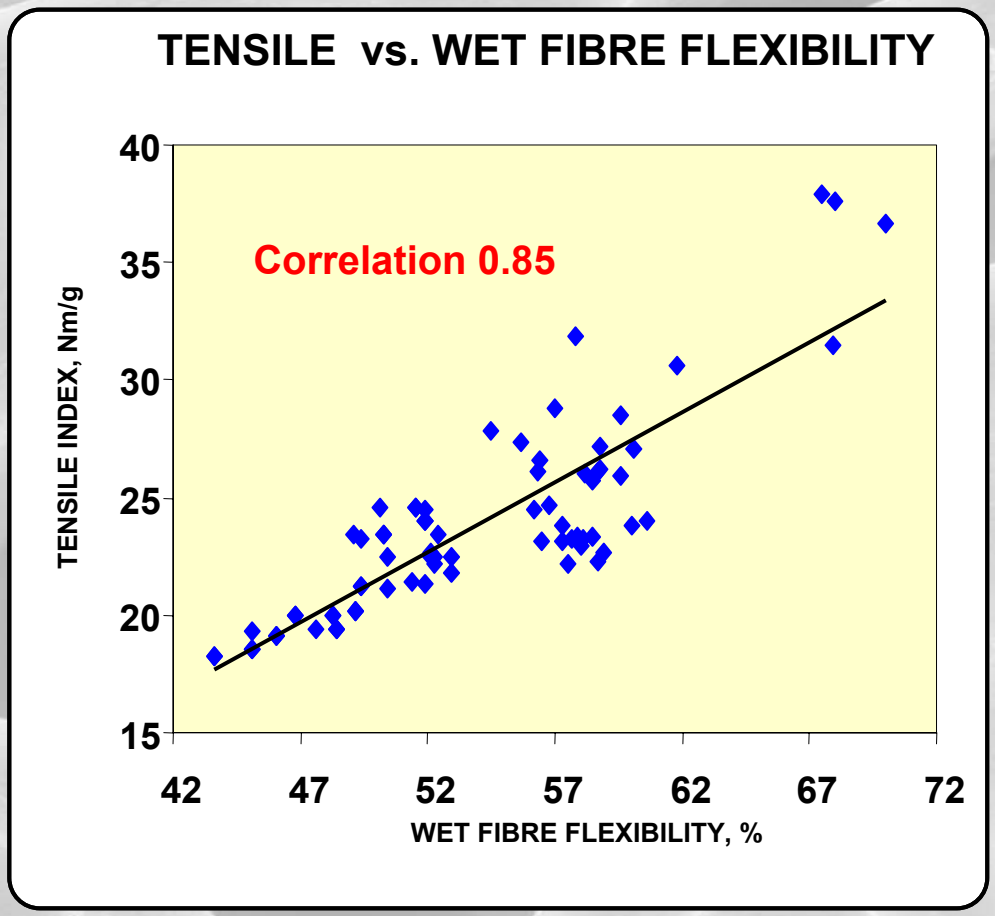
In other words…new exceptional results are now expected – *additional value* in the whole chain:

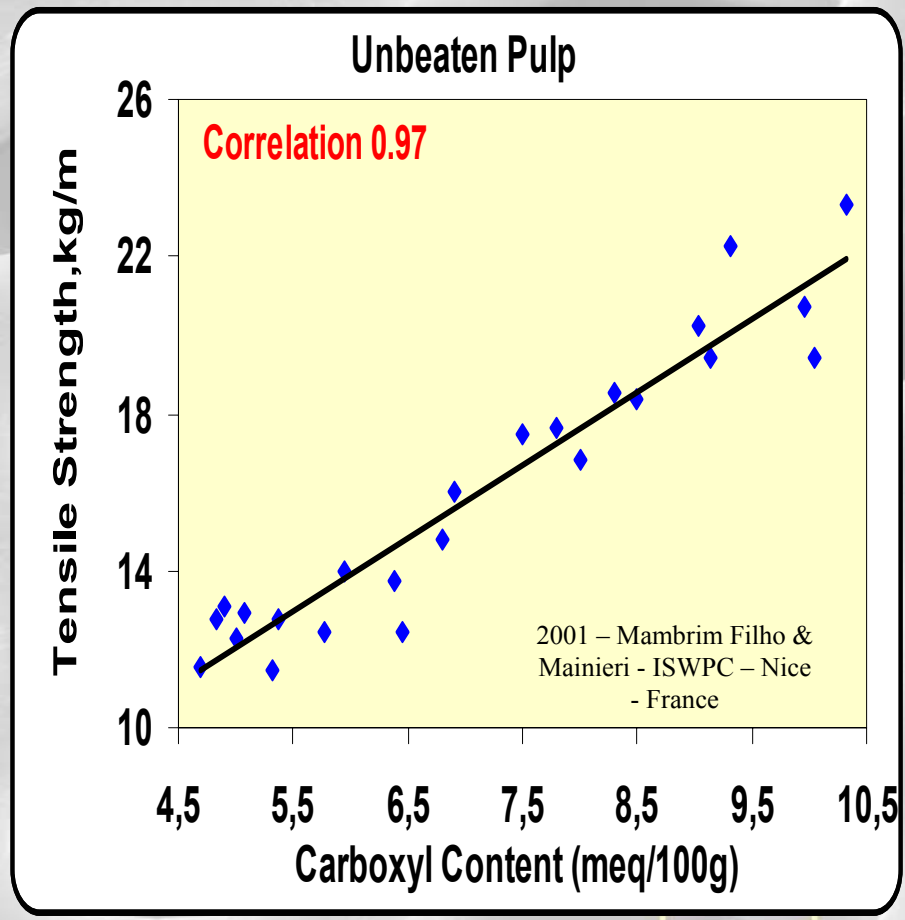


…and the application of selected and integrated mill process technology will deliver the fibre needed properties :

The "fiber platform" concept

Mill process segmentation





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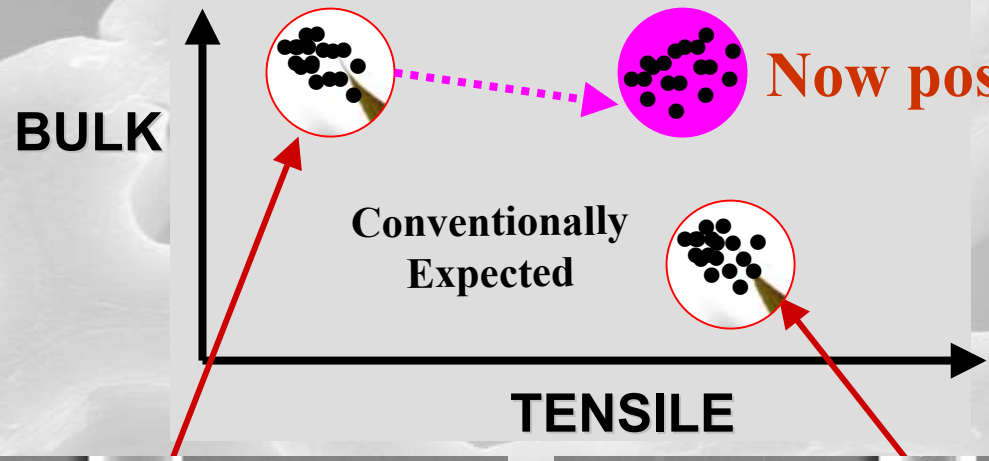
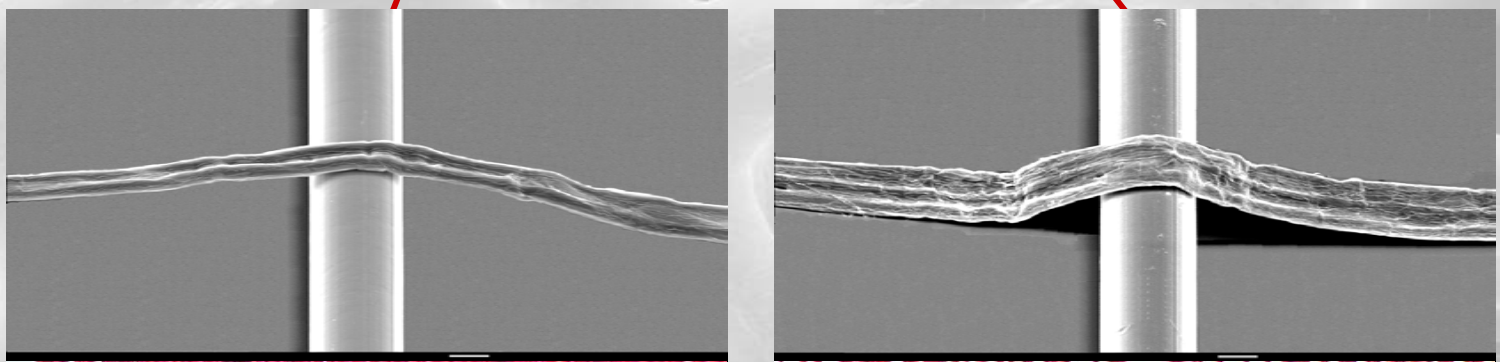
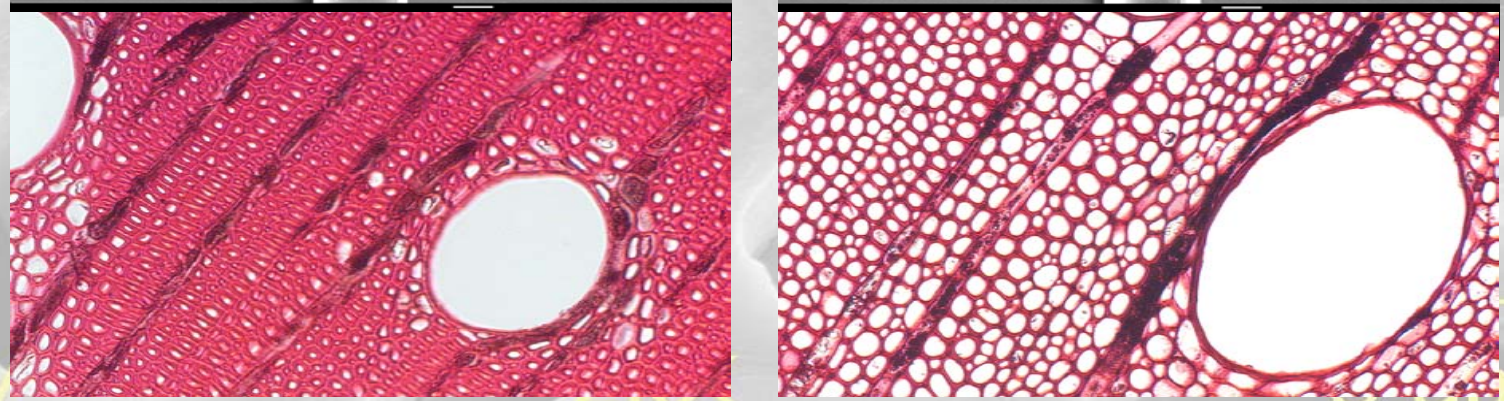
... Higher wood density in combination with special pulping process parameters have allowed higher tensile with comparable bulk



Wet fiber

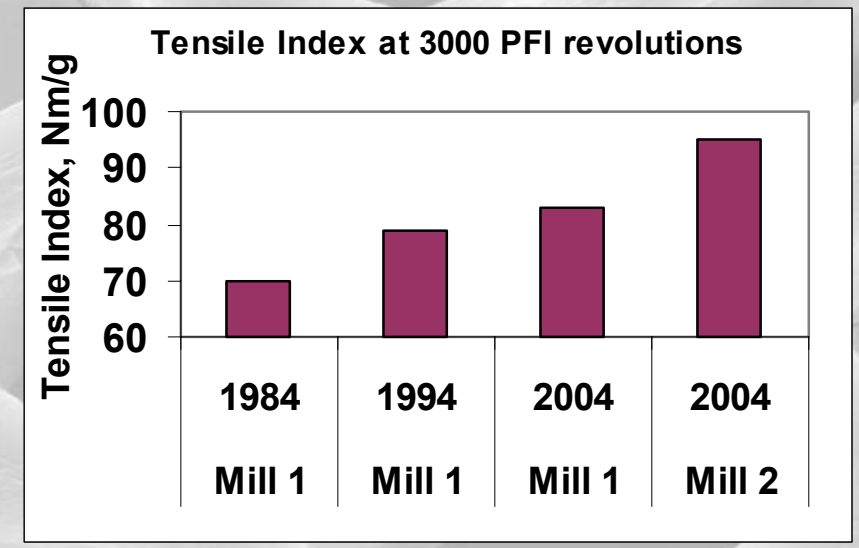


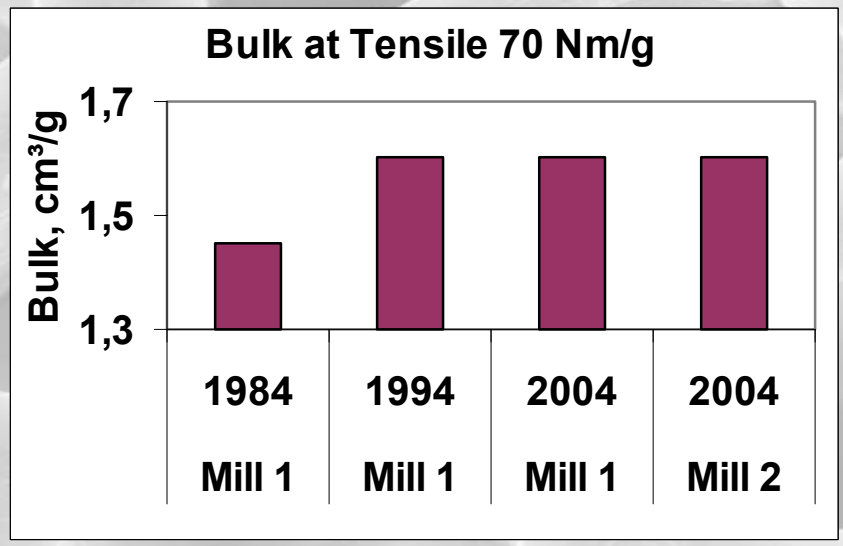
Wood

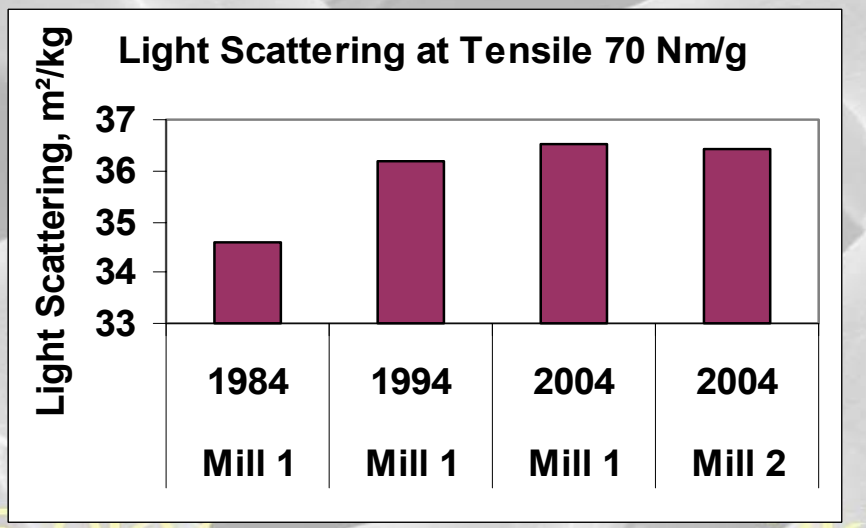


New targets are being achieved

Mill process segmentation - evolution







The interaction between controlled wood characteristics and optimized process parameters have enabled the achievement of adequate balance of properties

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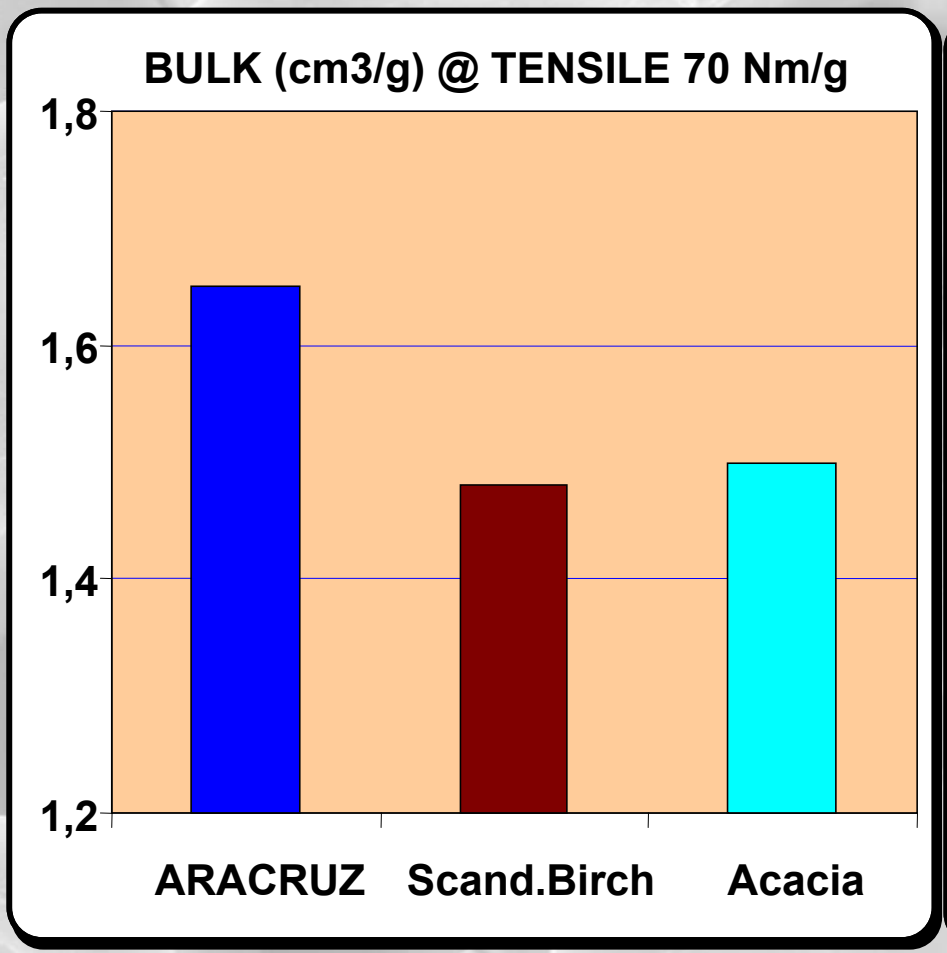
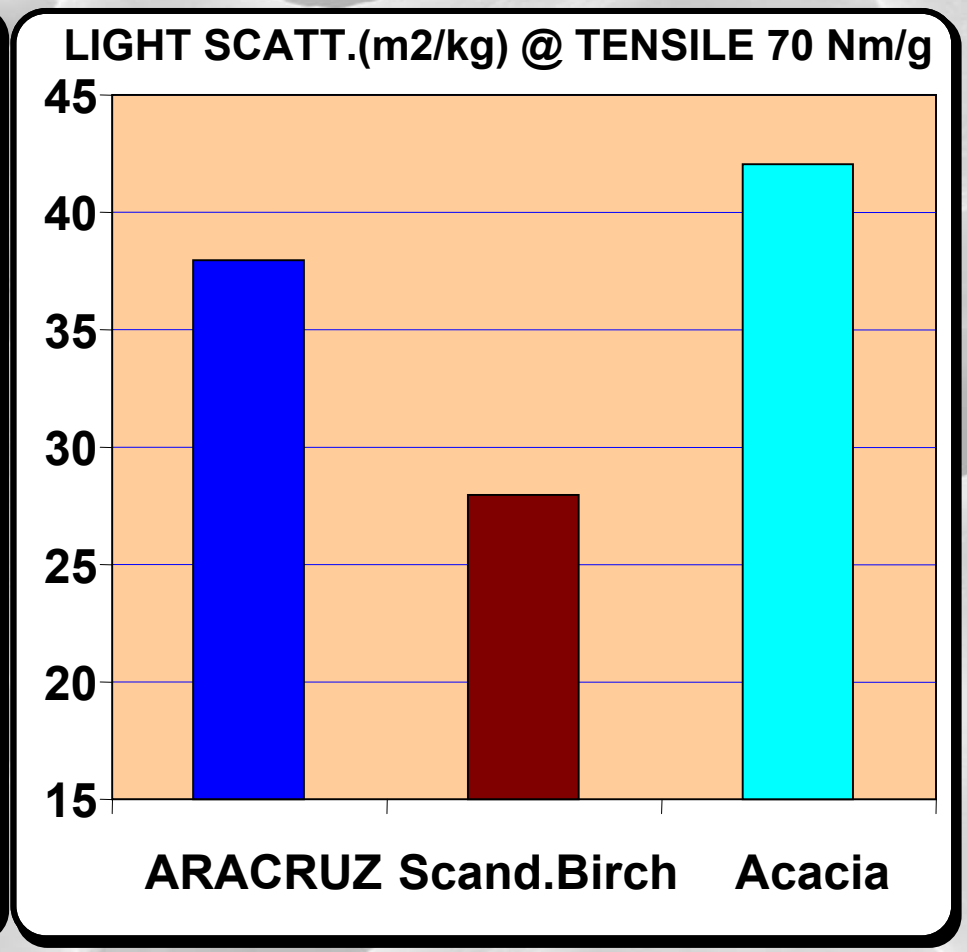
Aracruz and the Competition





What does the future look like?

New Clones with increased wood density

Wood and Fiber Caracheristics	Present Scenario	Near Future
Wood Basic Density, kg/m³	< 510	> 510
N° of Fibres per Gram, Million	18-20	> 24
Hemicellulose Content, %	16-18	> 18

15.0kV 2kX 5 um

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Final Remarks

Present results already obtained have confirmed that the integrated value creation process and the Fiber Platform Concept have provided significant cost and quality competitiveness .

15.0kV 1kX 10 um

Final Remarks - II

The balance of pulp and paper properties, as enabled by fiber characteristics, have met increasing demands from tissue and P&W paper markets, and have allowed the consolidation of Aracruz eucalypt as a premium BEKP.

Final Remarks - III

The future clone generation, with increased wood density, and improved fiber properties has indicated even higher potential to improve cost and quality competitiveness.

15.0kV 1kX 10 um

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Thanks!