RISI's Twelfth Annual Latin American Conference

The Impact of Genetic Improvement on the Forestry Value Chain

Clonal Eucalyptus Plantations in Brazil

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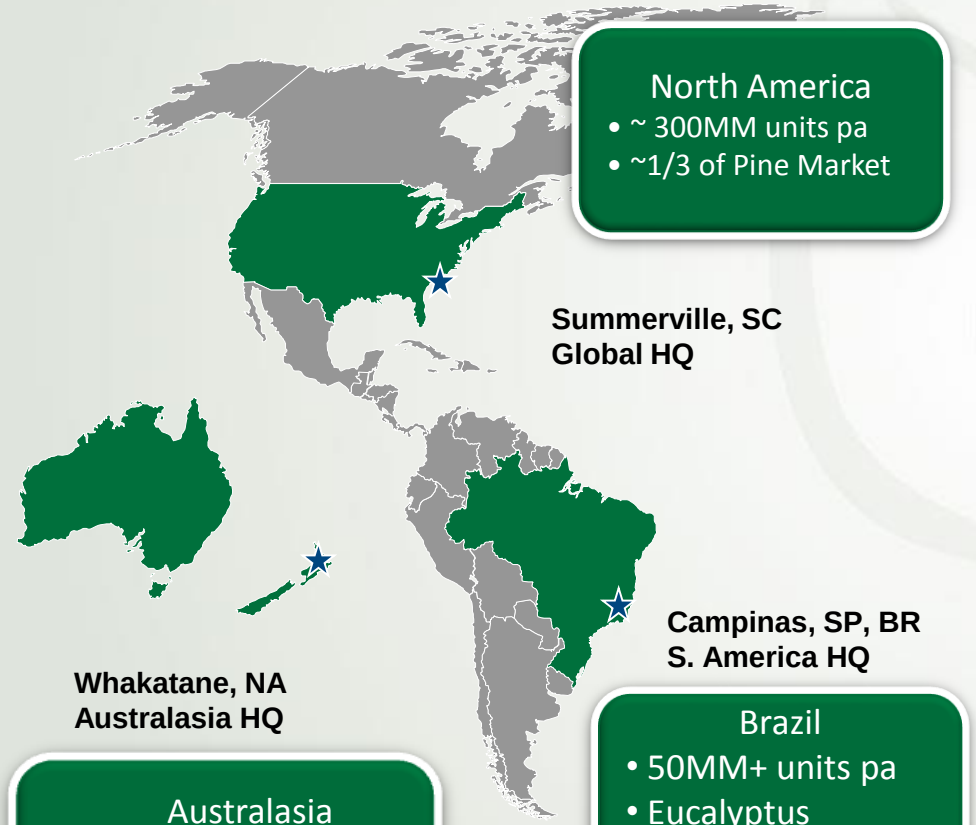
FORWARD-LOOKINGSTATEMENTS

There are statements in this presentation that are ‘forward looking statements.’ As these forward-looking statements are predictive in nature, they are subject to a number of risks and uncertainties relating to ArborGen and its operations and activities, some of which are beyond our control. As a result of the foregoing, actual results and conditions may differ materially from those expressed or implied by such statements.

ArborGen’s risks and uncertainties include - the global markets and geographies in which we operate, intellectual property protection, regulatory approvals, public and customer acceptance of genetically engineered products, customer adoption of advanced seedling products, the success of our research and development activities, weather conditions and biological matters.

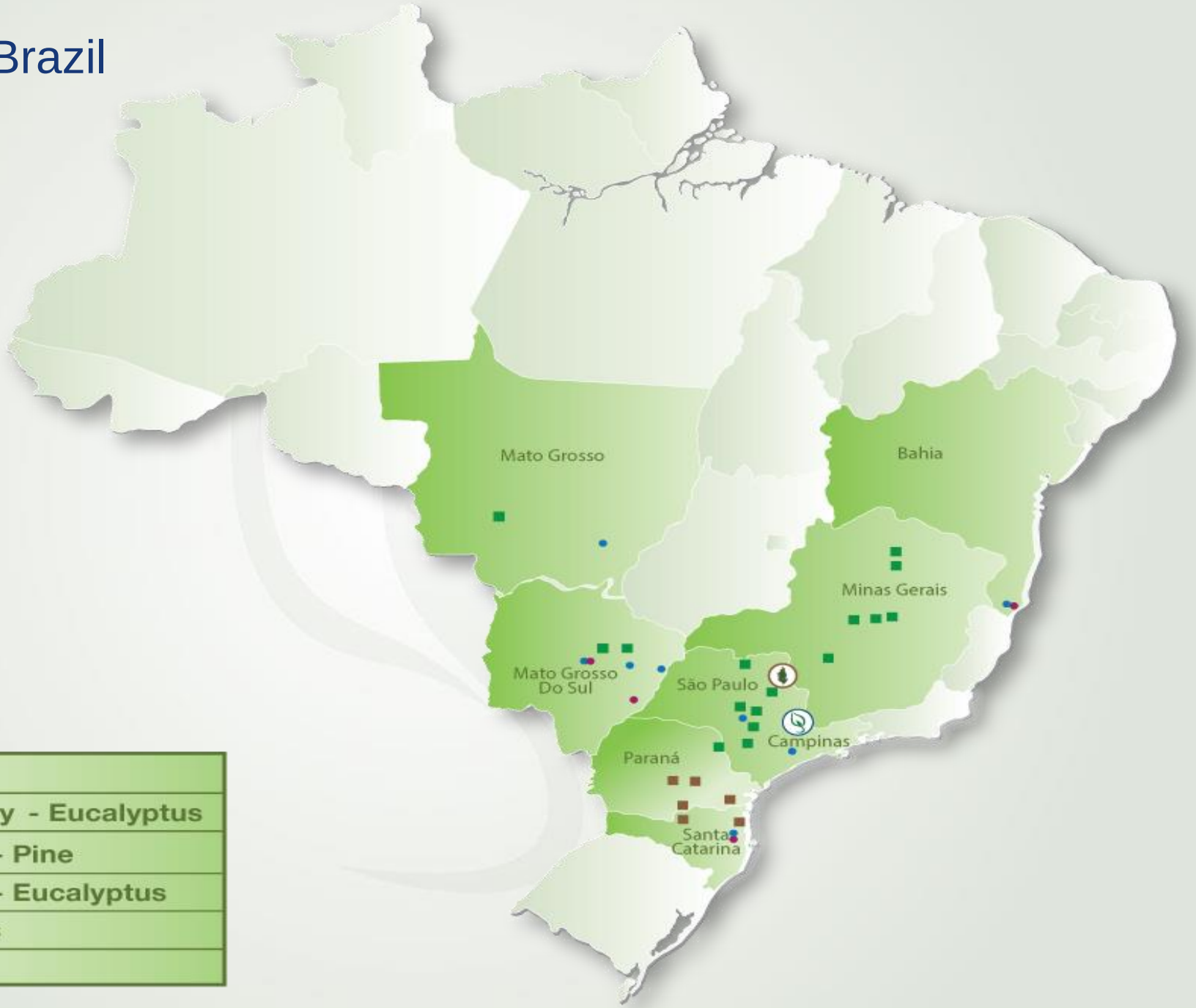
This presentation discusses different value outcomes for ArborGen products based on various input assumptions - e.g. silviculture, end-product pricing, discount rates, harvest timing, rotation, etc. These can each materially impact value and IRR. Assumptions outside those used herein could materially alter the analysis.

ArborGen is a Global Leader in Tree Improvement and Seedling Production



- **Leading seedling producer with ~ 370+ million trees per year**
- **Global operations**
  - **Southern U.S.**
  - **Brazil**
  - **New Zealand & Australia**
- **Providing step-changes in tree productivity**
  - **Faster growth**
  - **Improved log & wood quality**
  - **Disease resistance**
  - **Biomass production**

ArborGen do Brazil



	ArborGen Brazil
	ArborGen Nursery - Eucalyptus
	Nursery Partner - Pine
	Nursery Partner - Eucalyptus
	Eucalyptus Trials
	PineTrials

Executive Summary

The improved forest yields and wood properties associated with trees with improved genetics create significant value across the entire supply chain – from forest to mill

Land Owner

- Improved productivity per hectare (MAI)
- Reduced input costs
- Potential earlier harvest
- Every R$ spent on better genetics can return 7 to 11 X in revenue

Planting AG clones and managing a second rotation by coppicing increased profitability by 390%+ decreased establishment costs by 40%

Pulp Mill

- Lower delivered fiber costs
- Reduced chemical costs
- Improved throughput

The use of advanced genetics can reduce wood fiber costs per m3 by up to 16%

Energy Producers

- Lower delivered wood costs
- Improved energy density (kcal/kg

The use of advanced genetics can reduce the cost of biomass for energy production per kWh by 19%

Analytical Framework

- Using the June 2017 SisEucalipto version, EMBRAPA growth and yield simulator[1], the “optimal” regimes for maximizing returns (based on BLVs criterion) on investments were found. However, the selected harvesting ages were dictated by operational constraints.
- Incorporation of genetic gains into the existing G&Y models by EMBRAPA started in 2001 with a considerable number of temporary, permanent and experimental plots across Brazil.
- SisEucalipto provided the stand growth parameters (Dom Ht, TPH, QMD, BA, Total Yield, MAI and Assortment of products by diameter class) over the rotation age.

[1] Softwares para manejo e análise econômica de plantações florestais, EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária).www.cnpf.embrapa.br. Edilson Batista de Oliveira edilson@cnpf.embrapa.br

Volume Gains & Costs Using Three Clones Were Analyzed

Scenario: Two Cycles (first at age 6 and second/coppicing at age 12 years)

Control

- **MAI First Cycle 35.5**
- **MAI Second Cycle 32.0**
- **Gain: Base (0%)**
- Estbmt./mgmt. Costs[1]:
  - R$7,373/ha
- Seedling price:
  - R$330/M seedlings
- Differential:
  - R$0/ha
- **Fiber production**
- Stumpage price:

  R$ 47.5/ m^3

IPB2

- **MAI First Cycle 40.0**
- **MAI Second Cycle 36.0**

  Gain: 13% over the Control
- Estbmt./mgmt. Costs[1]:
  - R$7,549/ha
- Seedling price:
  - R$475/M seedlings
- Differential:
  - R$174/ha
- **Fiber production**
- Stumpage price:

  R$ 47.5/ m^3

IPB13

- **MAI First Cycle 42.0**
- **MAI Second Cycle 38.0**
- **Gain: 18% over the Control**
- Estbmt./mgmt. Costs[1]:
  - R$7,549/ha
- Seedling price:
  - R$475/M seedlings
- Differential:
  - R$174/ha
- **Fiber production**
- Stumpage price:

  R$ 47.5/ m^3

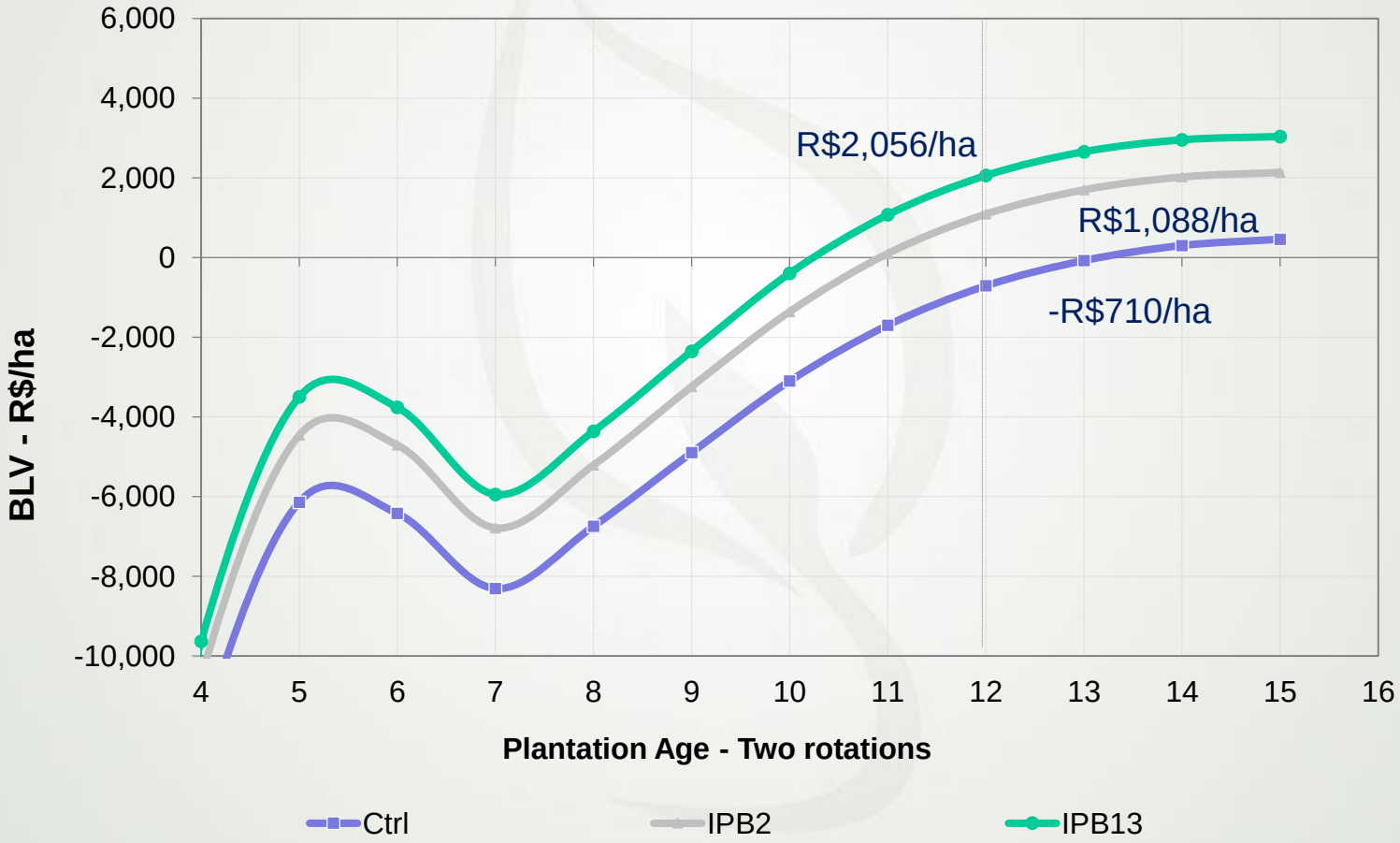
[1] **Total establishment costs (R$/ha @ Yr. 0 through Yr. 6)**

2017 Base Case Silviculture Regime

Year	Activity	Ctrl R$/ha	IPB2 & IPB13 R$/ha
0	Chemical site prep (Pre/post emergence herbicide application)	780	780
0	Establishment costs (tillage, irrigation, planting, replanting…)	1,675	1,675
0	Seedlings, Clone 1: $0.33, Clones 2 and 3: $0.475	**396**	**570**
1, 2	HWC	360	360
0	Fertilization (Limestone, N, P2O5, K2O, natural P)	1,500	1,500
1	Fertilization (N, P2O5, K2O)	880	880
0	Ant control	300	300
1, 3	Ant control	150	150
CC - 6	**First cycle / Clearcut**		
6, 7	HWC	360	360
6	Fertilization (Limestone, N, P2O5, K2O, natural P)	1,500	1,500
7	Fertilization (N, P2O5, K2O)	880	880
6	Ant control	300	300
7, 9	Ant control	150	150
7	Sprout thinning	278	278
CC - 12	**Second cycle / Final harvest**		
	Annual tax & administration costs	176	176
	Road maintenance	34	34
	Total R$/ha (Present Value)	10,398	10,572

Landowner Analysis

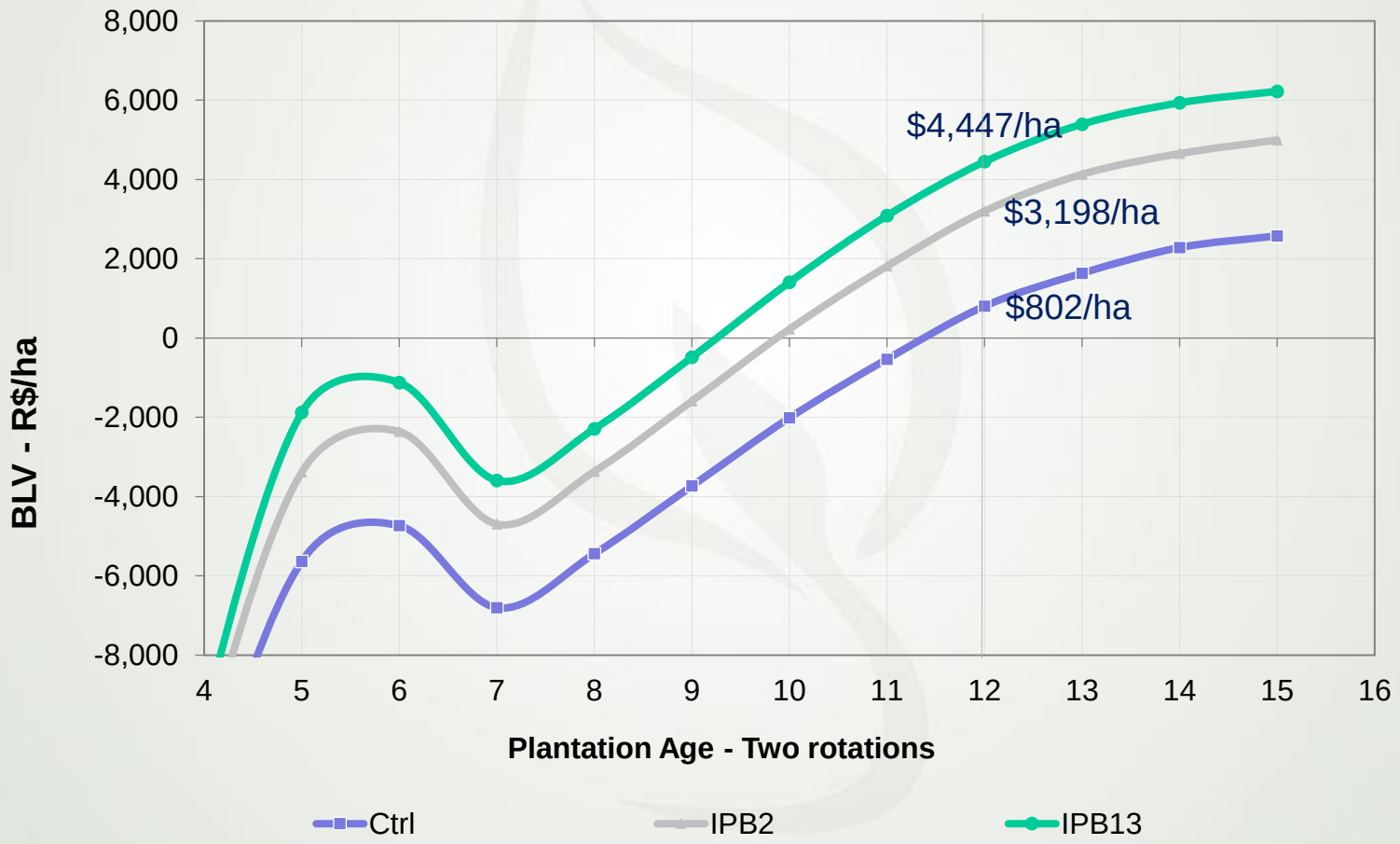
Selection of the Optimum Rotation Age
One Product (PW), 8% Real Discount Rate, Coppicing



* Stumpage timber prices (Mato Grosso do Sul, Pöyry, 2016): Pulpwood = R$47.5/$m^3$

Selection of the Optimum Rotation Age

Multiple Products*, 8% Real Discount Rate, Coppicing



* STCP Stumpage timber prices (R$/m^3): Energy = R$23.7, Pulpwood = R$46.6, Sawlog 1: R$93.0, and Sawlog 2 = R$66.9/m3

Landowner Financial Metric Summary:

Pulpwood @ R$ 45/m³

Genotype	Avg. MAI	BLV	NPV	Revenue[1]	Regime	Marginal
	m3/ha/y	R$/ha	R$/ha	R$/ha	IRR (%)	IRR (%)
Ctrl	33.7	-1,567	-945	23,806	6.2%	Base
IPB2	37.9	123	74	26,810	8.1%	26.8%
IPB13	39.9	1,041	628	28,203	9.1%	30.9%

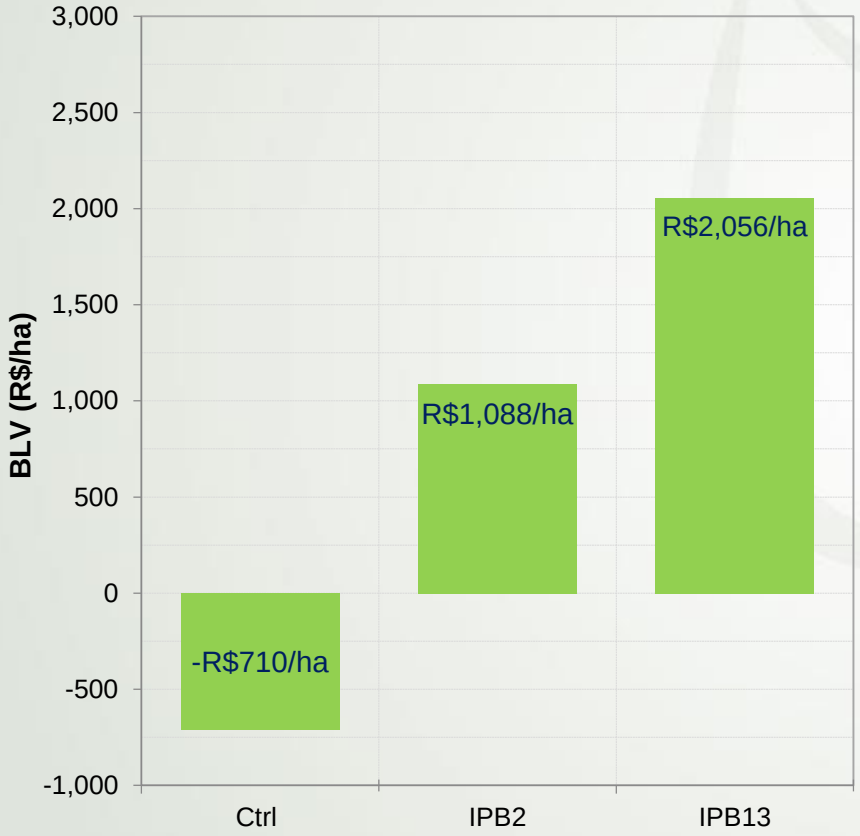
Pulpwood @ R$ 50/m³

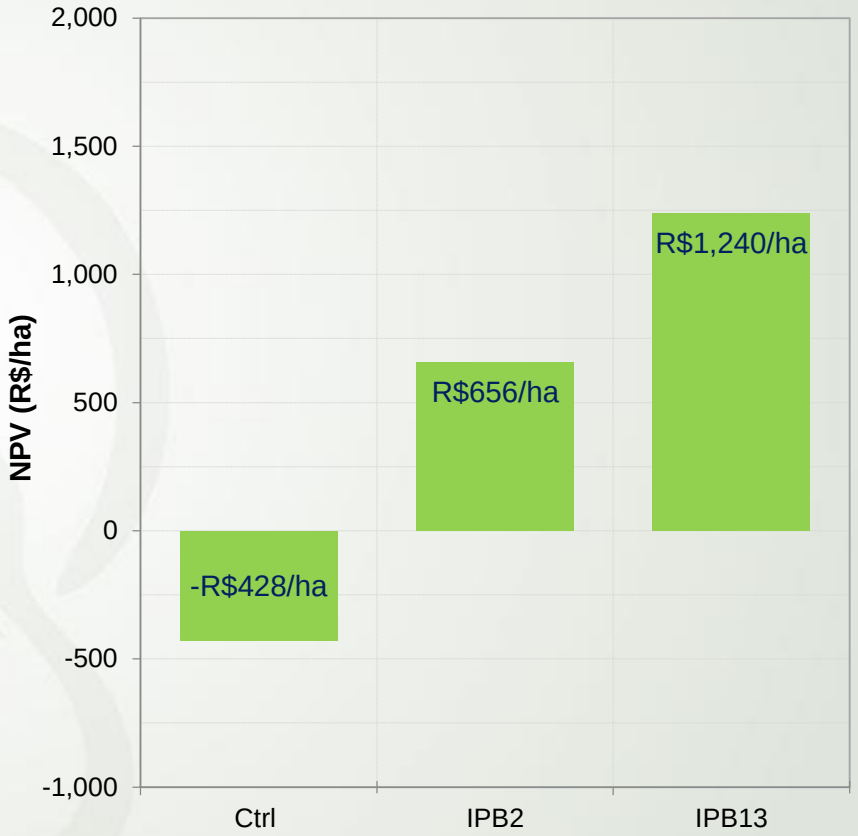
Genotype	Avg. MAI	BLV	NPV	Revenue[1]	Regime	Marginal
	m3/ha/y	R$/ha	R$/ha	R$/ha	IRR (%)	IRR (%)
Ctrl	33.7	176	106	26,451	8.2%	Base
IPB2	37.9	2,085	1,257	29,789	10.2%	27.9%
IPB13	39.9	3,105	1,872	31,337	11.2%	32.0%

Pulpwood @ R$ 55/m³

Genotype	Avg. MAI	BLV	NPV	Revenue[1]	Regime	Marginal
	m3/ha/y	R$/ha	R$/ha	R$/ha	IRR (%)	IRR (%)
Ctrl	33.7	1,918	1,156	29,097	10.0%	Base
IPB2	37.9	4,047	2,440	32,768	12.0%	28.9%
IPB13	39.9	5,169	3,116	34,471	13.0%	33.1%

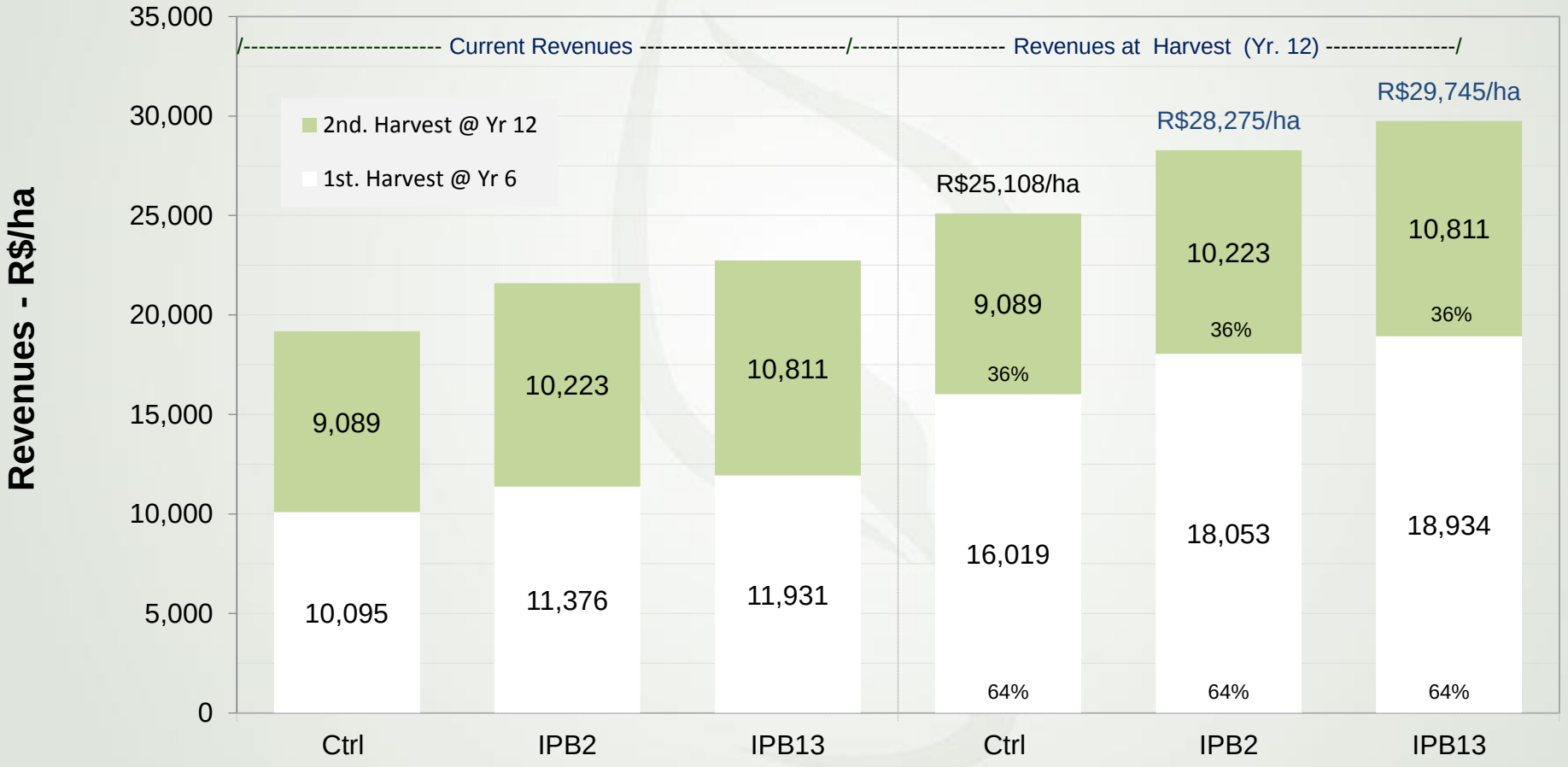
Increase in Value is Strongly Dependent on Volume





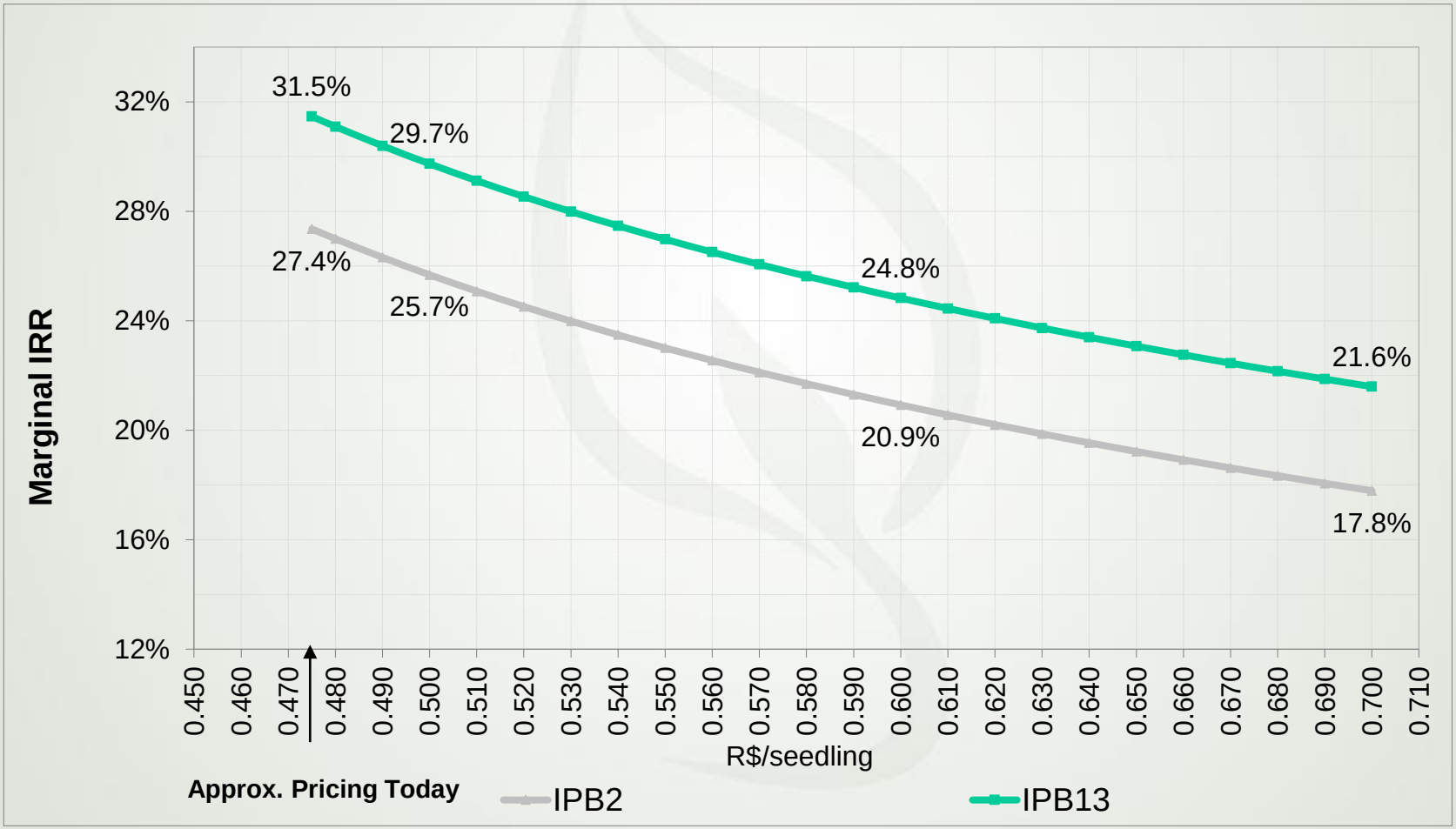
***** Stumpage timber prices (Mato Grosso do Sul, Pöyry, 2016): Pulpwood = R$47.5/m3

Total Revenue for AG Products: IPB2 and IPB13 over Ctrl Eucalyptus Plantations



* Stumpage timber prices (Mato Grosso do Sul, Pöyry, 2016): Pulpwood = R$47.5/$m^3$

Landowner Marginal Return on AG Investment
Two Cycles, Fiber Products Only



- All figures based on stumpage price of $R47m^3$.

BLVs (R$/ha)

Varying PW stumpage prices (R$/m³) and Real Discount Rates

Ctrl

IPB2

IPB13

Real Discount Rates

R$/m3 ↓	8.0%	10.0%	12.0%
45	-1,567	-2,621	-3,320
50	176	-1,292	-2,265
55	1,918	37	-1,209

R$/m3 ↓	8.0%	10.0%	12.0%
45	123	-1,367	-2,355
50	2,085	130	-1,166
55	4,047	1,626	23

R$/m3 ↓	8.0%	10.0%	12.0%
45	1,041	-670	-1,803
50	3,105	904	-553
55	5,169	2,478	697

Holding Harvest Ages Constant

Benefits to ArborGen Clients Two Cycles

Using AG Clones Seedlings for Fiber Production, Forest Landowners Can Expect:

- This analysis shows that ArborGen Eucalyptus Clonal Seedlings priced at $0.475 can create attractive value, returns and reduced wood costs across all scenarios considered in this analysis.
- Planting higher genetics increases the chance of achieving financial goals with less risks

Financial Criteria	IPB13	IPB2	Ctrl
BLV	R$ 2,056/ha	R$ 1,088/ha	-R$ 710/ha
NPV	R$ 1,240/ha	R$ 656/ha	-R$ 428/ha
IRR AG Seedlings	31.5%	27.4%	0.0%
Revenue 1st Cycle	R$ 11,931/ha	R$ 11,376/ha	R$ 10,095/ha
Revenue 2nd Cycle	R$ 10,811/ha	R$ 10,223/ha	R$ 9,089/ha

- All figures based on stumpage price of $R47m³.

End User Analyses

Eucalyptus for Pulpwood

- Increased tree growth decreases delivered wood prices which increases mill profits
- Increased pulp yields from higher specific gravity and elevated cellulose to lignin ratios reduce pulp costs and wood consumption[1]

Eucalyptus for Energy

- Sustainable, renewable and cleaner wood-based power production
- Lignin is the most energetic component of wood due to the high level of aromaticity, size, arrangement of its structure and high carbon content[2]

[1] Peter, G., D. White, R. De La Torre, R. Sing. 2007. *The value of forest biotechnology: a cost modelling study with loblolly pine and kraft linerboard in the southeastern USA .* Int. J. Biotechnology, 9(5):21p.
[2] Pereira, Bárbara Luísa Corradi. 2012*. Wood quality of Eucalyptus for charcoal production*. M. Sc., Universidade Federal de Viçosa. 102p.

Pulp Mill Analysis

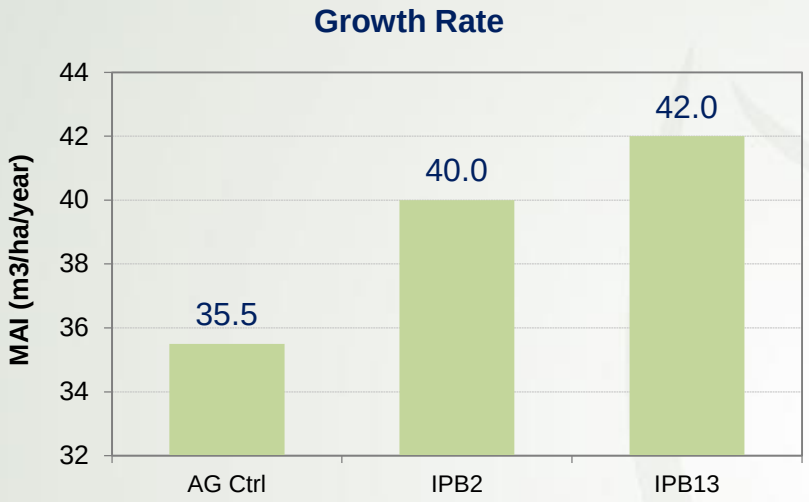
Pulp Mill Analysis Summary

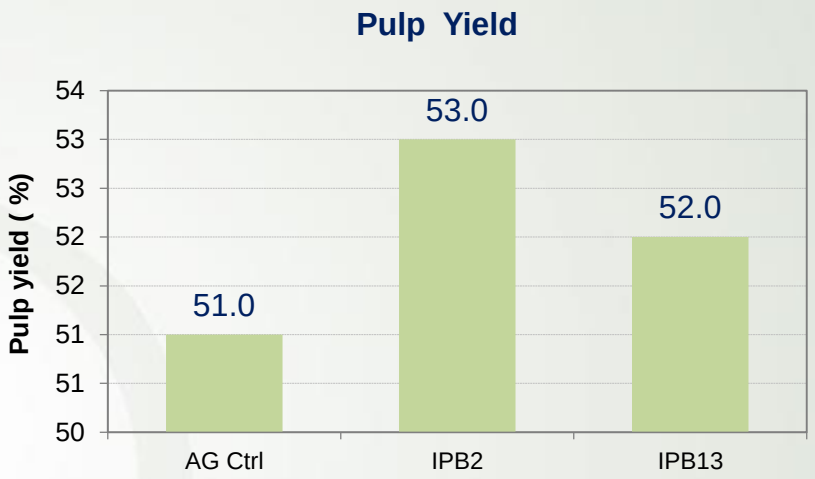
The use of advanced genetics adds value throughout the supply chain

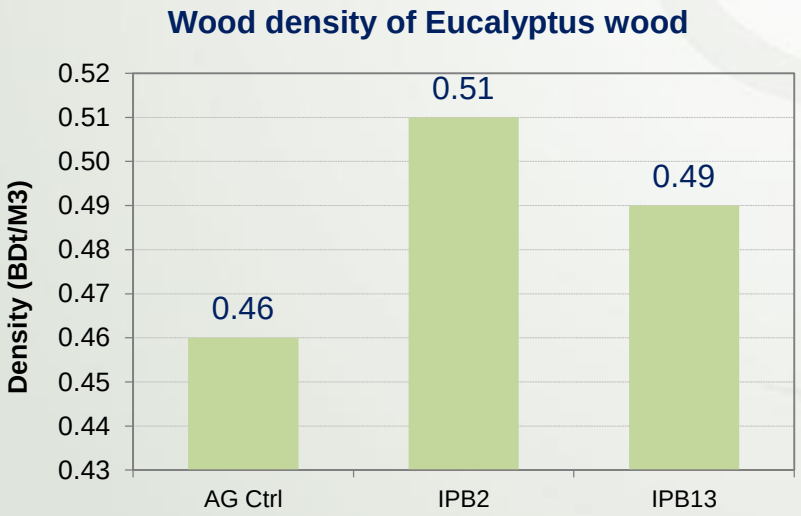
1. Silvicultural and wood properties are both important value drivers
    - Growth and yield: MAI (m^3/ha/yr.)
    - Density
    - Lignin content
    - IMACel
2. Impact is comprehensive
    - Land base
    - Harvesting costs
    - Freight costs
    - Freight logistics

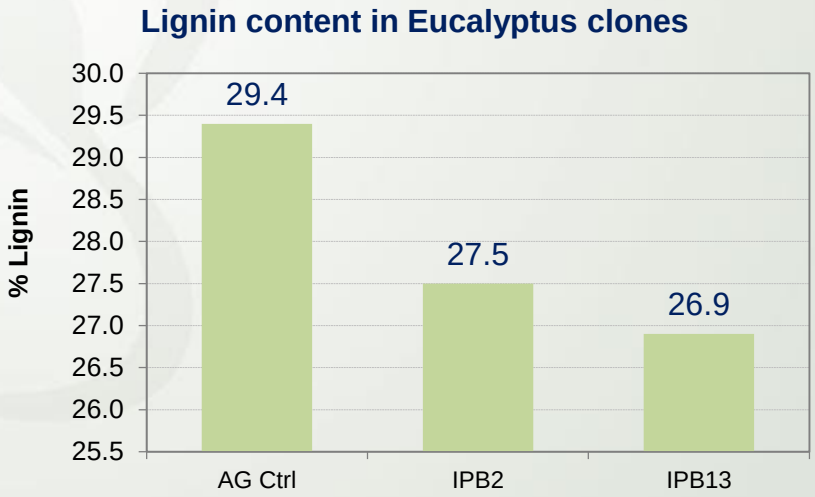
Trees with improved genetics also improve mill efficiencies and further reduce pulp costs. These benefits are not included in this analysis.

Growth and Wood Properties

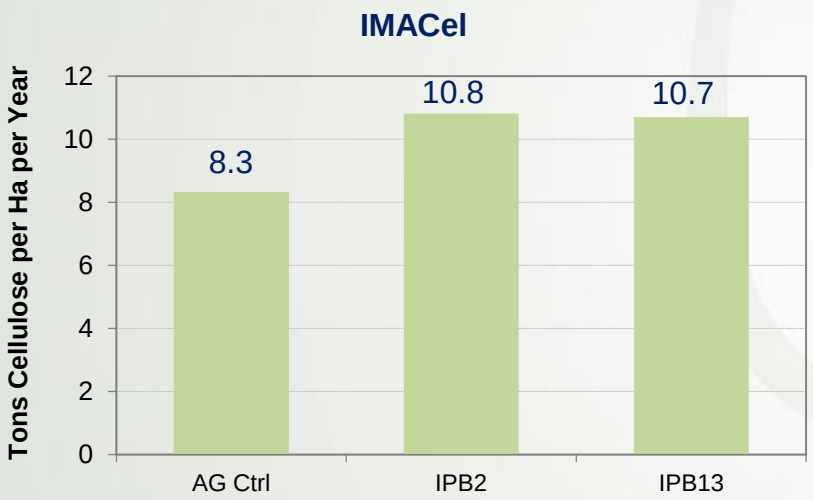


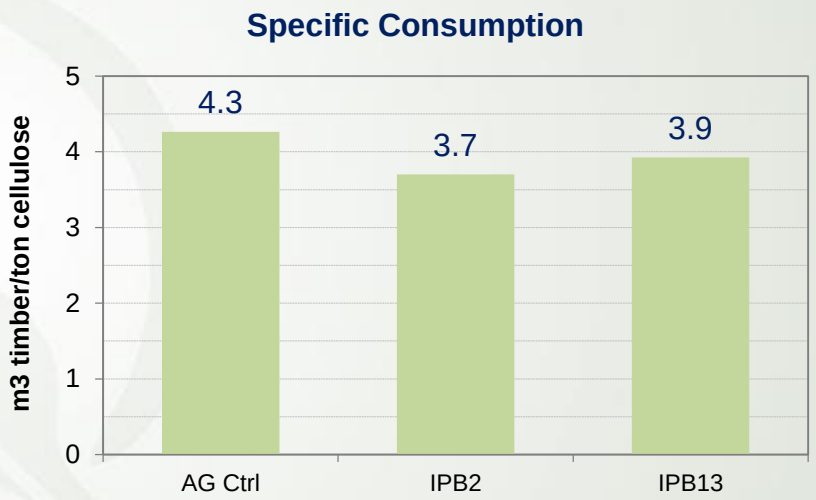






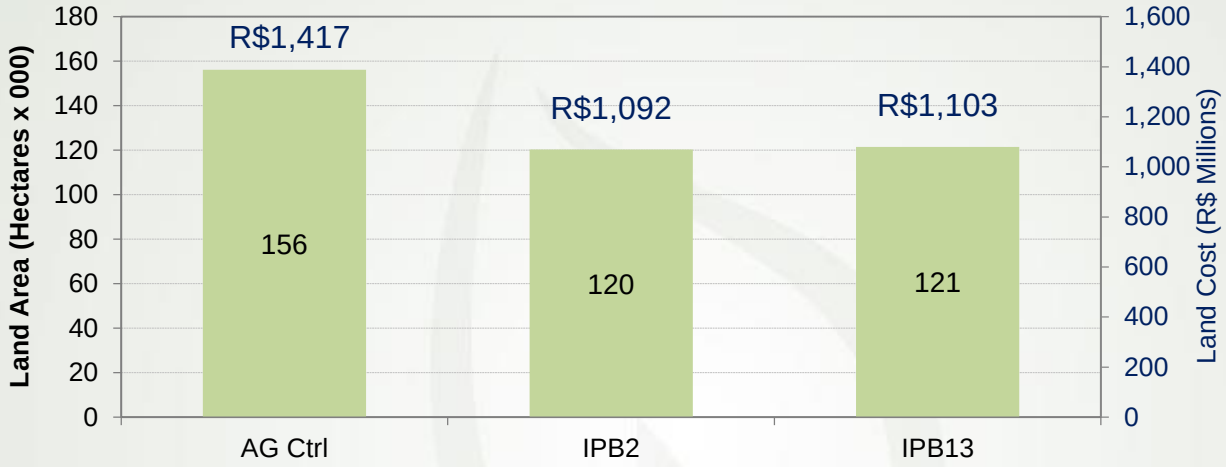
Pulp Yield, IMACel and Wood Consumption Per Ton of Pulp



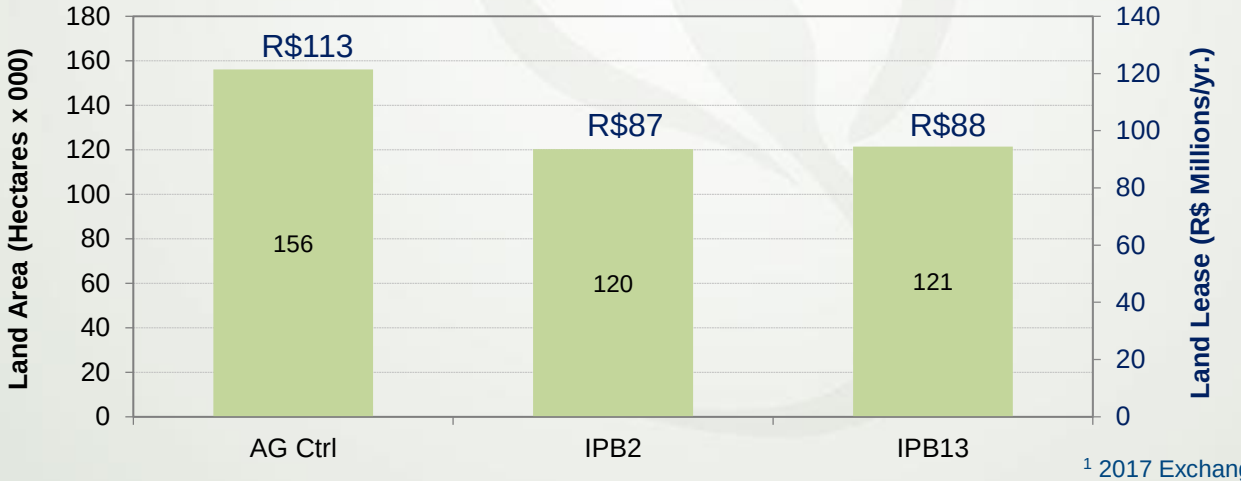


Land Investment

Land Base



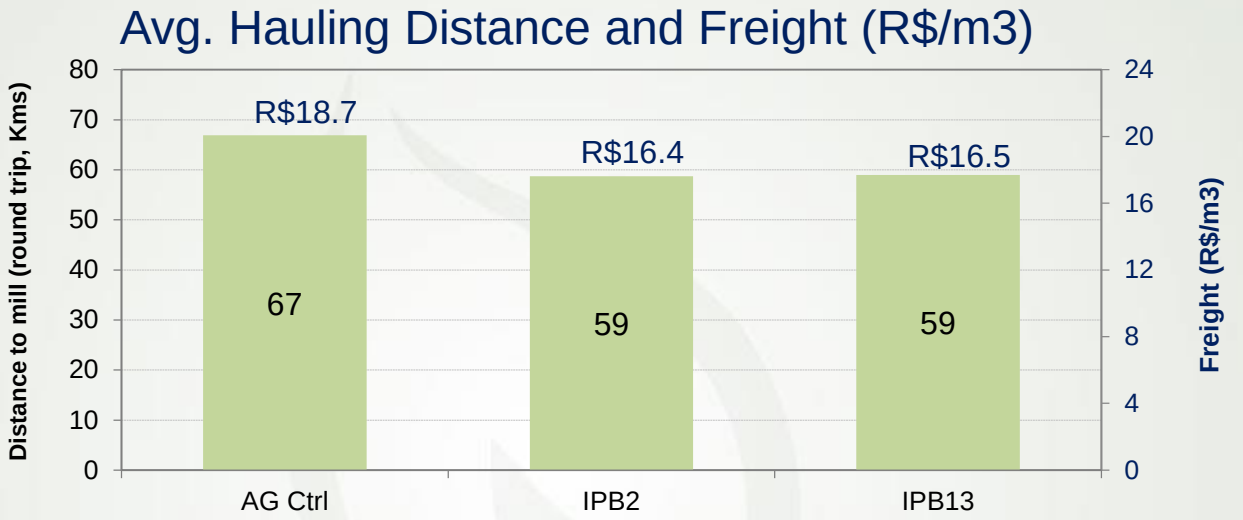
Annual Land Lease

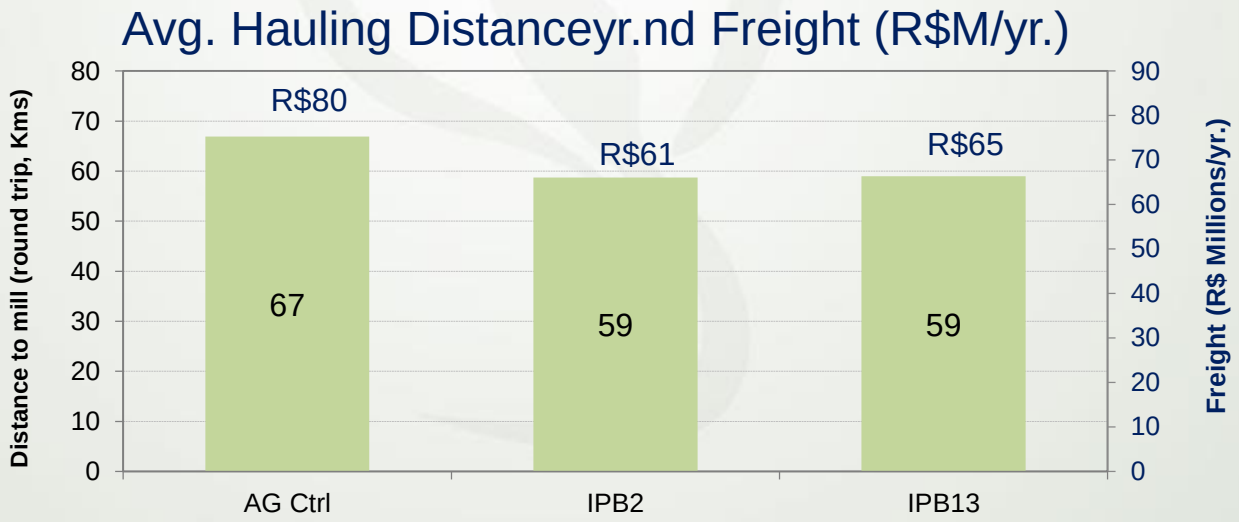


[1] 2017 Exchange rate: US$ 1 = R$ 3.632

Results for a mill with capacity of 1 million air dry metric tons per year

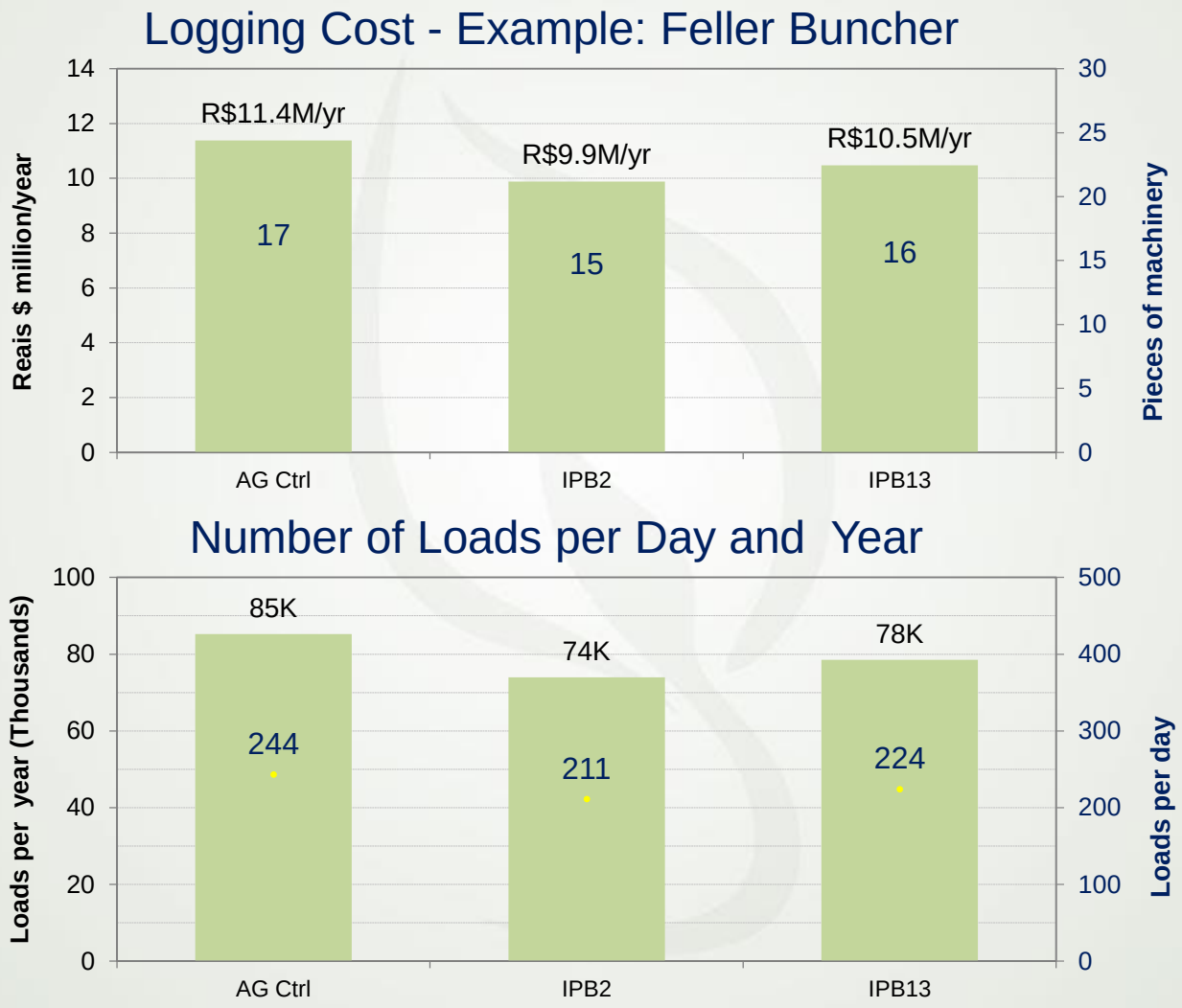
Transportation Costs





Results for a mill with capacity of 1 million air dry metric tons per year

Harvesting Cost



Results for a mill with capacity of 1 million air dry metric tons per year

Summary: Land Base, Hauling Distance, Freight & Harvesting

Results for a mill with capacity of 1 million air dry metric tons per year

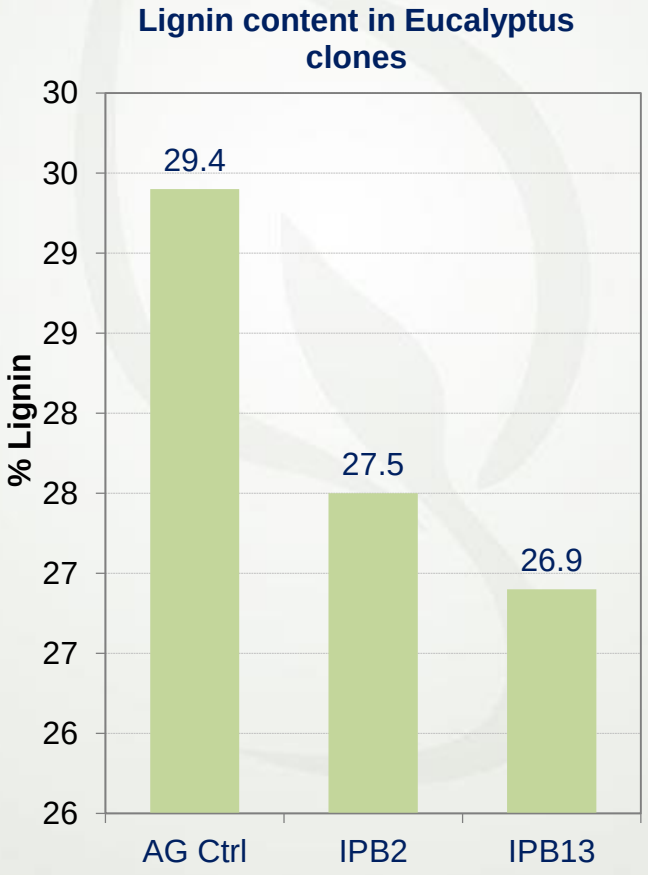
Resources and operations	AG Ctrl	IPB2	IPB13	Expected savings/gains	
				IPB2	IPB13
MAI Cel, ton.cel/ha/yr	8.3	10.8	10.7	2.5	2.4
MAI Cel (ton.cel/ha planted)	50.0	64.9	64.2	14.9	14.2
M3 timber/ton cellulose	4.3	3.7	3.9	-0.6	-0.3
Yearly mill consumption of wood (m3)	4,262,575	3,699,593	3,924,647	-562,982	-337,928
Gross land base (hectares)	156,094	120,237	121,477	-35,858	-34,617
Land cost (R$M)	1,417	1,092	1,103	-326	-314
Land lease (R$M/ha/yr., at 8%)	113	87	88	-26	-25
Hauling radius distance (kms), round trip	66.9	58.7	59.0	-8.2	-7.9
Haul Rate (R$/m3) Avg. distance	18.7	16.4	16.5	-2.2	-2.1
Haul Rate (R$M/yr.)	79.5	60.8	64.8	-18.7	-14.7
Logging Cost (R$M/yr. for feller-buncher)	11.4	9.9	10.5	-1.5	-0.9
# pieces of machinery / logging crews	17	15	16	-2	-1
Number of Loads/yr.	85,251	73,992	78,493	-11,260	-6,759
Number of Loads/day	244	211	224	-32	-19
Approx. Annual Savings (R$M/yr)	⋮	⋮	⋮	**46***	**41**

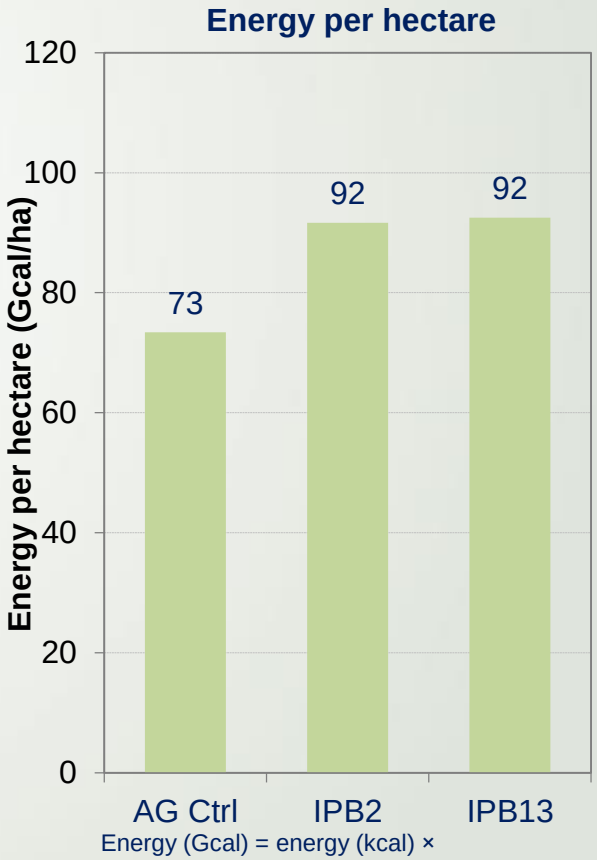
***Represents reduction in wood fiber costs per m³ by up to 16%**

Electricity Plant Analysis

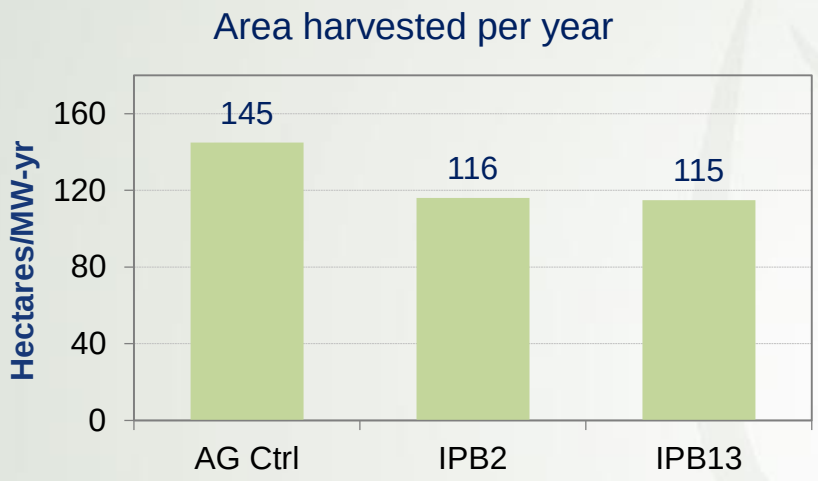
Energy Per Hectare by Clone

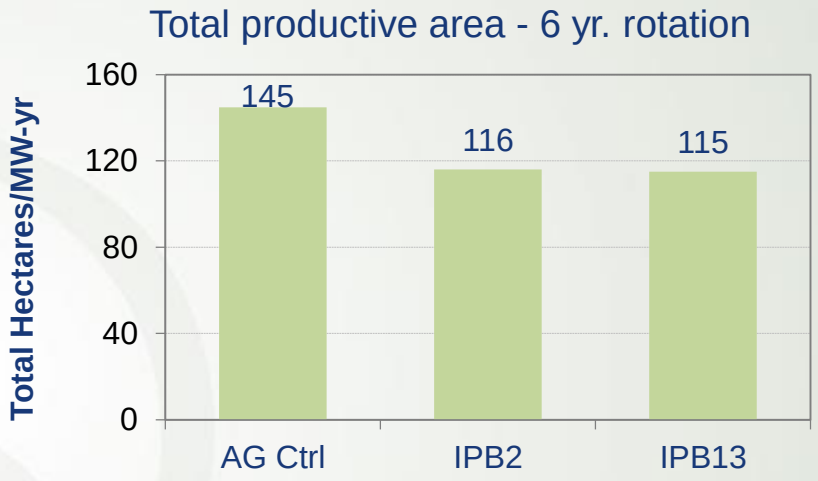
- Lignin is the most energetic component of wood (Pereira, 2012)
- The greatest potential for improving mill profitability comes from increased wood specific gravity more than increased biological growth rates (Lowe et al., 1999)

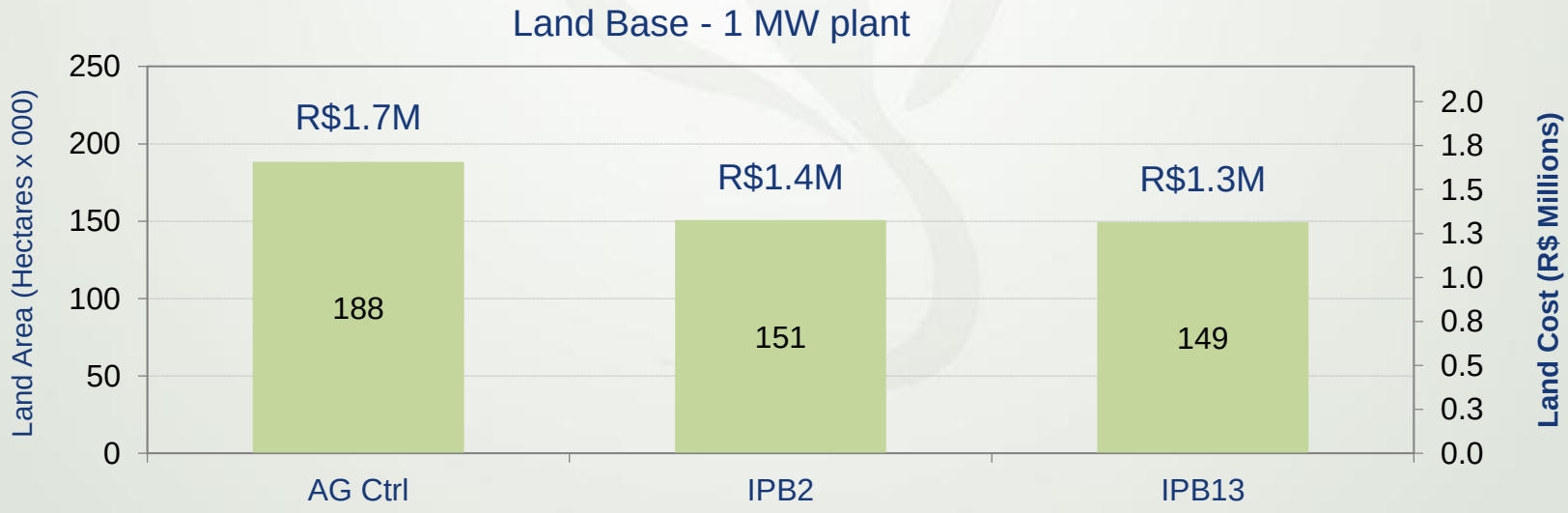




Area Required as a Function of Installed Power Plant (1MW)

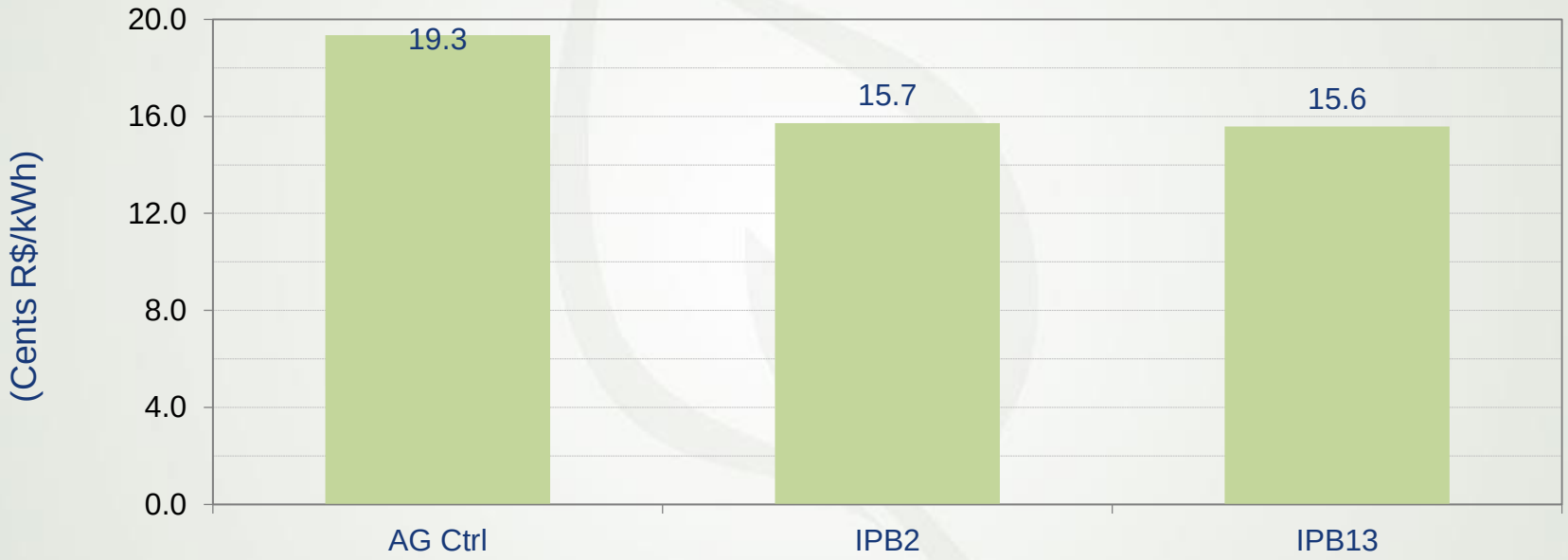






Energy Production Costs

Biomass contribution to energy costs (including land rent, first cycle)



Cost of electricity per kWh: 44-91 R$ cents per kilowatt hour (Ex. rate: 1 USD = R$ 3.632)
https://en.wikipedia.org/wiki/Electricity_pricing, 2016

Summary: Impact of Advanced Genetics on 1MW Power Plant

Energy and Land	AG Ctrl	IPB2	IPB13	Expected savings/gains	
				IPB2	IPB13
MAI, m3/ha/yr	35.5	40.0	42.0	4.5	6.5
% Lignin	29.4	27.5	26.9	-1.9	-2.5
Density, ton/m^3	0.46	0.51	0.49	0.05	0.03
Bone Dry Tons, BDT/ha/yr	16.33	20.4	20.58	4.1	4.3
Energy per hectare (1000 x kcal / ha)	73,386	91,677	92,485	18,290	19,099
Hectares/MW-yr	145	116	115	-29	-30
Total Area harvested per year (hectares)	24	19	19	-5	-5
Total Area, hectares	188	151	149	-38	-39
Land cost (R$M)	1.7	1.4	1.3	-0.3	-0.3
Land lease (R$/ha/yr x 1000, at 8%)	136	109	108	-27	-28
Energy production costs (Cents/kWh)	19.3	15.7	15.6	-3.6	-3.8

Conclusions

- Advanced genetics bring significant value to the entire Brazilian fiber supply chain, from forest to mill.
- These benefits arise from both increased productivity per ha. and improved wood properties.
- Determination of the value arising from these benefits requires situation specific analysis.
- This analysis will almost always demonstrate that investments in advanced genetics offer very good returns – no matter where you are in the value chain.
- While the value of advanced genetics is generally recognized by the Brazilian value chain, market organizational dynamics sometimes interfere with the capture of that value.


Thank You
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