RENTABILIDADE POR M³ DE DIFERENTES ESPÉCIES DE EUCALIPTO PARA O OESTE PAULISTA

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RESUMO

O eucalipto é a maior fonte de madeira renovável no Brasil e vem se expandindo nos últimos anos para diversas finalidades. Porem a produção está consolidada em áreas tradicionais ou vinculadas a novas indústrias de manufaturas. O Oeste Paulista é uma região localizada estrategicamente entre todas as cadeias produtivas, mas com poucos investimentos e sem nenhum estudo sobre a capacidade de produção da região. Analisamos e delineamos a região com características climáticas e de solo similares para verificar as possibilidades de investimentos e foram plantados 100 eucaliptos das 10 espécies mais usadas no Brasil totalizando 1000 exemplares e foram monitorados de 2013 a 2016 para analisar quais espécies teriam melhor incremento médio de volume de madeira. Entre as com melhores ganhos destacamos as espécies 1277 e I144 que melhor se adaptaram e a espécie *E. tolleriana* obteve pior performance. Além disso analisamos os preços nacionais e indicamos as espécies que dariam maior faturamento para os agricultores que optarem por esse investimento.

Palavras-chave: Ambiente econômico, administração florestal, economia florestal.

PROFITABILITY PER M³ OF DIFFERENT EUCALYPTUS SPECIES AT THE WEST OF SAO PAULO – BRAZIL

ABSTRACT

Eucalyptus is the largest source of renewable wood in Brazil and has been expanding in recent years for various purposes. However, production is consolidated in traditional areas or is linked to new manufacturing industries. The West of Sao Paulo (*Oeste Paulista*) is a region strategically located among all the production chains, but with little investment and without any study on the region's production capacity. We have analyzed and outlined the region with similar climatic and ground characteristics to verify possibilities of investments and it were planted 100 eucalyptus trees of the 10 species most currently used in Brazil totaling 1000 samples which were monitored from 2013 to 2016 to analyze which species would have better average increment of wooden volume. Among those with better gains, we point out the species 1277 and I144, which have adapted better and the specie *E. tolleriana*, which got the worse performance. Furthermore, we have analyzed domestic prices and we have indicated the species that would give greatest invoicing for farmers who opt for this investment.

Keywords: Environmental economics, forest Administration, forestry economics

INTRODUCTION: EUCALYPTUS IN BRAZIL

The increased demand for wood products is a global reality, and the concern about the use of native trees belongs to whole society, thereby the companies' response is to expand the number of forests planted, being this phenomenon also Brazilian. Eucalyptus is one of the most planted wooden tree in Brazil and has great economic importance; likewise, it is featured in over one hundred countries.

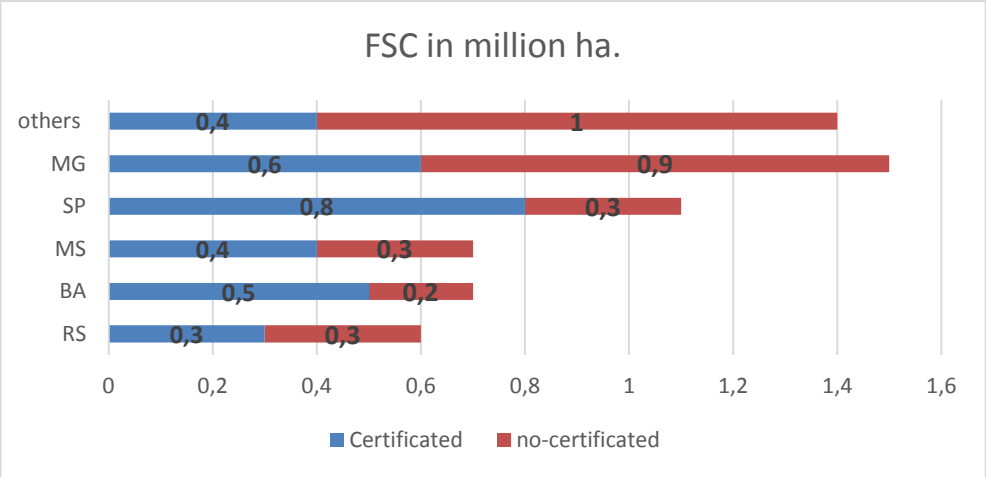
Originally from Australia with the exception of the species *Eucalyptus Urophylla* and *E.deglupta* (MORA; GARCIA, 2000). Currently there are more than 700 species already cataloged, many of them hybrids, to be adapted in different varieties of soil, sunlight and water conditions (BOSCARDIN, 2009). The first plantations focused on commercial production were made in Europe around 1854, in Portugal. In Brazil eucalyptus plantations on a commercial scale is dated back to 1909 being stablished through the São Paulo Railway Company to the manufacturing of sleepers (cross-ties) (MORA; GARCIA, 2000).

Although there are more than one century since the first commercial use of

eucalyptus in Brazil, the amount of areas, on Brazilian soil, planted and certified is not yet known: according to the Brazilian Forest Certification Program which represents the Programme for the Endorsement of Forest Certification (CERFLOR / PEFC), Brazil had 7.3 million hectares planted and 1.6 million certified in 2013, however, a different amount is showed by the Forest Stewardship Council (FSC) that states a planted area of 7.6 million hectares and 4 million hectares certified. On the other hand, the Brazilian Ministry of Agriculture (MAPA)[1] states that in 2015 Brazil had 6 million hectares. A lack of precision exists also in the micro regions since comparing the Federation States, the numbers of CERFLOR / PEFC and FSC differ and there are no official data by MAPA.

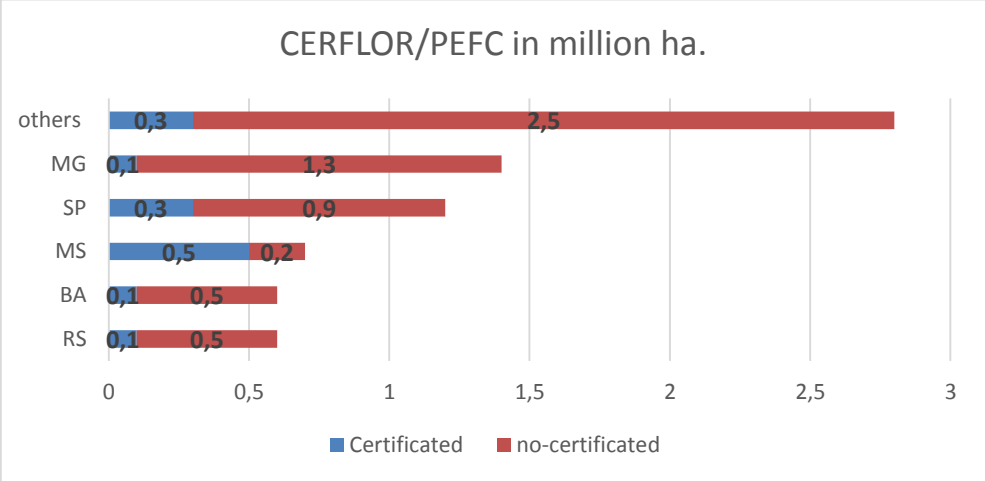
[1] MAPA is the Brazilian official agency on statistical data of agriculture. Available at: http://www.agricultura.gov.br/desenvolvimento-sustentavel/florestas-plantadas. Accessed on 01 fev.2016

Chart 1. Forest Stewardship estimated.



Source: FSC report adapted by the authors

Chart 2. Federation States estimated



Source: CERFLOR/PEFC report adapted by the authors

Regardless the imprecision, is remarkable the importance of Brazil on the international stage, since the eucalyptus plantations have as purpose the production of wood for energy, pulp and paper, mechanical processing, sawn wood and civil construction, furthermore, the Country has a large internal market and has been increasing its stake in exports linked to the pulp and paper industry.

What strikes is that the planted areas are directly distributed where the processing industries and final consumer market are. The Report of 2014 from the National Trees Industry (IBA) highlights the geographical correlation between planted areas and the final consumption. The map below shows trees planted by State in 2013.

Map 1. Trees planted by State in 2013.



Source: IBÁ reported in 2014, p. 49

Hereinafter the map shows the location of paper and pulp producers.

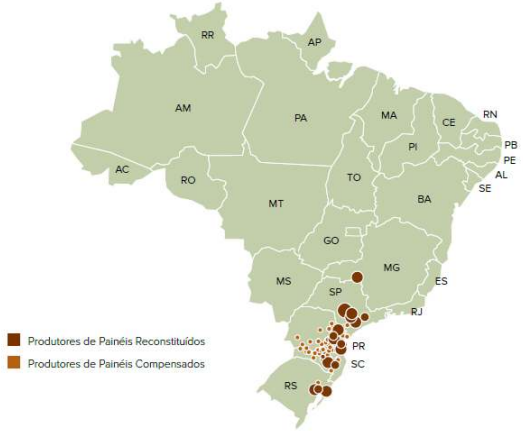
Map 2. Location of paper and pulp producers.



Source: IBÁ reported in 2014, p. 58

Following are reported the producers of wooden panels.

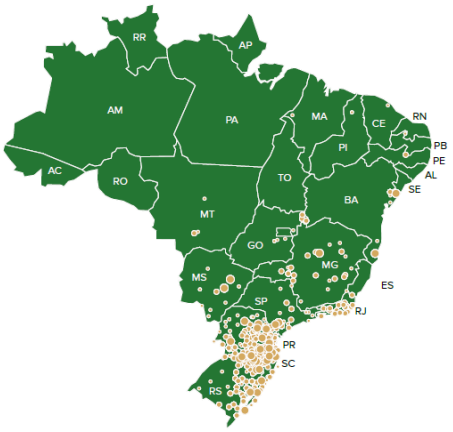
Map 3. Producers of wooden panels.



Source: IBÁ reported in 2014, p. 60

Here are highlighted the sawed wood producers.

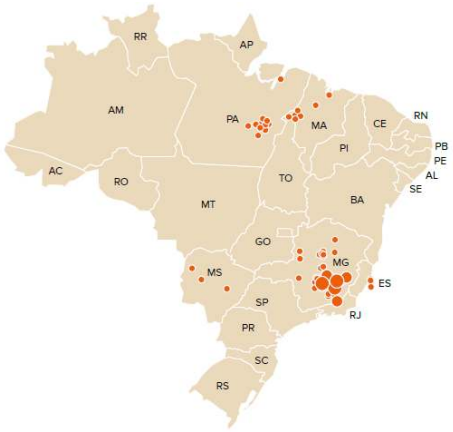
Map 4. Sawed wood producers



Source: IBÁ reported in 2014, p. 63

Next, the map shows the use of wood for energy purposes in steel industries.

Map 5. Use of wood for energy purposes in steel industries.



Source: IBÁ reported in 2014, p. 65

The state of São Paulo, represented by the acronym SP, has currently the second largest area of planted forest with eucalyptus in Brazil, having more than one million hectares (ABRAF, 2013). These numbers are given on the basis of investments made by companies in the paper and pulp segment, that have encouraged the plantation by providing seedlings, inputs and technical assistance, and ensuring to the producer, the purchase of his production.

It stands out not only the pulp and paper industry, but also timber, sawmills and construction. Nonetheless, when analyzing the western region of São Paulo State it is noticed the absence of a part of the productive chain in this region.

Following the maps are showed in sequence: plantation, pulp and paper, timber, sawmill and energy.

Map 6. Sequence of maps where are shown the location of the trees used for plantation, pulp and paper, timber, sawmill and energy, in the State of Sao Paulo, Brazil.



Source: IBÁ reported in 2014

This region is called "*Oeste Paulista*" and its economy stands out in the livestock sector, especially in the rearing of cattle - for milk and slaughter. It is noticed that in recent years the sugar-alcohol sector is standing out by the number of power plants in the region and the amount of acreage with sugar cane, approximately 1.3 million hectares according to IEA[2].

The dualism between farming/ livestock and ethanol can be broken in the region since the *Oeste Paulista* is strategically located in the middle of the main production chains of wood; therefore, we raised the hypothesis of a possible new frontier of eucalyptus in Brazil.

The *Oeste Paulista* has a history of latifundium in the past and was the Brazilian region that got more funds for agrarian reform. In addition, recently, large ethanol producers have settled in to lease idle land, but according to the Agricultural Research Group of the *Oeste Paulista* (Gpagro),[3] the region has one million hectares of fertile soil that has been degraded by the lack of investments. Despite this whole scenario, in the last ten years it was registered an increase of, in average, 2.300 hectares /year of planted area.

FROM GAP TO THE OPPORTUNITY

The resulting opportunity of a good geographical location is not enough, several other factors must be analyzed such as soil, water provision and, climatic conditions of sun exposure for example. Moreover, evaluate the types of eucalyptus that best suit the climate and soil conditions of the region aiming a greater productivity and profitability for the farmer. Therefore, this study had as purpose helping producers to have a better understanding about the eucalyptus species most profitable for planting.

The profitability of eucalyptus with gain of wooden m^3 in Brazil is above the world average, the Annual Average Increment (IMA) in Brazil is on average $40m^3$/ha/ year of wooden with the cut in approximately 7 years (CIB, 2008). However, this natural competitive advantage has never been tested in the *Oeste Paulista* region.

The *Oeste Paulista* has a soil that is different from the traditional producing regions, and despite the eucalyptus not be too demanding about the soil, the planting productivity is also related to soil characteristics, temperature conditions and water availability that influence the growth.

SOIL

According to Mora and Garcia (2000), eucalyptus adapts itself better in deep soils, well drained and without impediment layers. However, according to Baptista e Levien (2010) having the knowledge of soil and relief attributes, aids in the proper management and can foster an increased productivity.

The relief is crucial to the productivity of planting forests, since it determines differentiated conditions for the soil formation, influencing also in the drainage conditions and in the resources availability for the growth of trees (BALIEIRO et al., 2008). Another factor that must be quoted because it influences in the productivity is the lack of water in the soil.

WATER DEFICIENCY

The reduction of available water in the soil for the eucalyptus cultivation, has negative influence in its productivity, resulting hence in a low profitability, at the same time, having the required water amount will give to the tree the conditions of a better development.

Stape (2002) has concluded that the water supply was the main element controller of eucalyptus productivity and of the use of natural resources, as well as in the periods of water deficit, timber production is significantly affected. According to Dye (2000) extended periods of water deficit can significantly reduce the productivity of eucalyptus plantations and may also contribute to an increase in mortality.

Nonetheless, there are some varieties of species and hybrids adaptable to different climatic conditions, developed to have greater resistance mainly to the water deficit. However, the highest productivities are found in regions where there is no water deficit (MORA; GARCIA, 2000) and where are found optimal temperatures and the growth reaches its highest rate.

[2]IEA is the Institute of Agricultural Economics of São Paulo State and responsible for the State official data. Available at: http://www.iea.sp.gov.br/out/bio-estatistica.php Accessed on 02 Jan. 2017

[3]GPAGRO is a research group from the *Oeste Paulista* University that analyzes the soil of the *Oeste Paulista* region. Available at: http://sites.unoeste.br/gpagro/ é um grupo de pesquisa da Universidade do Oeste Paulista que busca analisar o solo do Oeste Paulista. Accessed on 22 Jan. 2017

TEMPERATURE

Temperature is one of the main climatic elements that affects the growth of trees. It is responsible for the photosynthesis, which is a very important factor for the growth and development of plants and has great interference in productivity.

The air temperature according to Streck (2004) is a major weather element affecting the development of most plant species. Moreover, Battaglia; Beadle; Louchhead (1996) state that the air temperature, among all the abiotic factors, is the one that directly influences in the eucalyptus growth.

In accordance with Salisbury; Ross (1991), the ambient temperature changes significantly influence the growth of plants. Changes in few degrees occurring in the natural environment usually lead to significant changes in growth rates, being the minimum temperature defined as that below which there is no growth; optimal temperature, where the plant reaches the maximum growth rate and, maximum temperature, the temperature value above which there is no growth and the plant can die.

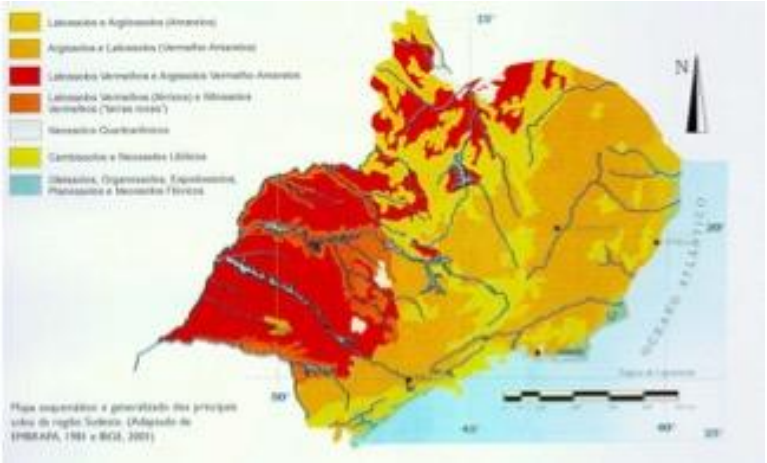
In order to know the particularities of the *Oeste Paulista* region and understand the soil characteristic, water capacity and, temperature conditions. To this experiment, we have chosen the soil of *Presidente Prudente* city that has the same characteristics of the region.

According to the Agronomic Institute of *Campinas* (IAC), the soil of *Presidente Prudente* is classified as Acrisol Red - Yellow being a sandy soil with expectations of low or moderate productivity. These type of soils, predominant in the region have low uniform clay content along the profile and dry out easily (VICENTE; ARAUJO, 2013).

The water capacity of the region is poorly known from the point of view of the micro regions. In addition, the only existing weather stations are located in *Presidente Prudente* where the average annual rainfall is of 1254.9 mm. Regarding the temperature, the region has a minimum annual average of 14 °C, average of 23.6 °C and maximum of 27.9 °C.

Soil data are confirmed by official data and the region has a relatively weak soil, presenting predominantly the red Latosols and red-yellow Argisol, represented by the red color on the map (EMBRAPA, 2006).

Map 7. The region has a relatively weak soil, presenting predominantly the type of soils: red Latosols and red-yellow Argisol, represented by the red color on the map.



Source: Embrapa, 2006.

To obtain the average temperature of the region, we did a cutout of the last 4 years and found that the average temperature between 2012 and 2015 was 23.85 degrees Celsius (INPE – CPTEC)[4].

[4] Available at: http://clima1.cptec.inpe.br/ Accessed on 10 Jan. 2017

Chart 3. Detailed information about the temperature between 2012 and 2015, whose average was 23.85 degrees Celsius, according with the INPE – CPTEC.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2012	24.4	26.6	25.4	23.7	20.4	19.7	20.1	23.2	24.6	26.5	25.7	26.9	23.9
2013	25.1	25.2	25.1	22.8	21.9	20.7	19.3	20.5	23.1	23.9	25.0	26.7	23.3
2014	26.4	27.1	25.3	23.9	21.1	20.9	19.7	23.0	24.1	26.2	24.9	25.7	24.0
2015	27.6	25.8	24.9	24.4	21.0	21.1	20.2	23.4	24.8	27.4	23.2	26.1	24.2
Average	25.9	26.2	25.2	23.7	21.1	20.6	19.8	22.5	24.2	26.0	24.7	26.4	23.8

Source: CPTEC adapted by the authors

Regarding water availability, in the last four years there was a small variation and, considering only the rains that occured in the period analyzed, the average was 1448.5 millimeters per year (INPE – CPTEC)[5].

[5] Available at: http://clima1.cptec.inpe.br/ Accessed on 10 Jan. 2017

Chart 4. Detailed information regarding the water availability, in the last four years where the average was 1448.5 millimeters per year, according with the INPE – CPTEC.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
2012	179.6	103.2	110.2	127.4	111.0	233.6	21.2	0.0	137.0	50.4	108.0	299.6	1481.2
2013	162.0	183.2	150.6	195.6	108.2	112.4	42.6	4.8	102.0	104.4	111.2	127.2	1404.2
2014	188.4	104.8	113.4	140.0	64.8	9.2	76.2	16.0	131.4	57.8	207.4	179.0	1288.4
2015	141.4	221.0	183.4	101.4	160.0	21.2	136.6	15.6	125.4	90.1	265.9	190.9	1652.9
Average	163.93	169.67	149.13	145.67	111	47.6	85.133	12.133	119.6	84.1	194.83	165.7	1448.5

Source: CPTEC adapted by the authors

As we have seen, there are several species of eucalyptus with several applications in different silvicultural sectors, and the lack of academic research may cause serious damages, because producers could make not assertive choices. A more appropriate species selection, choosing that one which best develops in a region, according with the purpose desired through its planting, will bring to the farmers a best profitability and, on the other hand, a wrong choice could bring damage and/or low profitability.

THE TUME (TEST OF EUCALYPTUS' MULTIPLE USE)

We have analyzed 10 species in our empirical test, verifying also their commercial purposes. The clones I144 and H13 are hybrid of *E. urophylla* and *E. gradis* that associated the characteristics of the species that originated them such as, good capacity for regrowth and high volumetric performance (DESCRIÇÃO..., 2003). On the other hand, the clone 1277 is a hybrid that combines the species *E. grandis* and *E. camaldulenses*, that is, it has high performance and versatility with tolerance to water deficit.

The *E. tolleriana*, has good ability to regrowth, however, it is susceptible to water deficit and demands a soil moderately fertile, with good drainage (DESCRIÇÃO..., 2003).

With a relatively heavy wood, the species *E. pellita* has highest properties of mechanical resistance. It is considered suitable for regions where do not occur frosts. In Brazil, this species has not been widely planted and few studies have been conducted. In addition, some studies done by research institutions are not encouraging. (DESCRIÇÃO..., 2003). *E. resinifera* is one of the most important species in Australia, whose wood is used in sawmills, furniture, wooden boxes, dormant, poles, fence posts, firewood and charcoal. The species is susceptible to frost and water deficit, and has good ability to regrowth. However, in Brazil this species has not been widely planted due to the lack of studies about it (DESCRIÇÃO..., 2003).

The other species used are originating from the species *E. urophylla* (Uro 110 and Uro AN 189), *E. saligna* (0020) and *E. grandis* (AN) that have arisen through genetic improvement programmes of Companies and/or Research Institutions that try to select individuals with superior characteristics to reproduce through the vegetative propagation in their clonal forest nurseries (DESCRIÇÃO..., 2003)

E. urophylla by having a good ability to adapt itself in slightly sandy soils, at different altitudes, is suitable for areas where there are no frosts and severe water deficit situations. In Brazil, the species has been extensively planted in breeding programs, especially hybridization and, it has good capacity of regrowth. Considered one of the most versatile species and suitable for multiple use, the *E. saligna* adapts itself to slightly sandy soils and is considered suitable for regions where do not occur frosts nor severe water deficit situations. The species has been widely planted in Brazil having the second largest acreage of the country. It is a species tolerant to low heat and has high ability to sprout ((DESCRIÇÃO..., 2003).

E. grandis is the main raw material for the pulp industry; it is considered sensitive to severe frosts and it presents a relative resistance to water deficit. Its wood is considered moderately slight, with a differentiated heartwood. It has good ability to regrowth and its growth rate and volumetric efficiency are generally higher when compared to other species (DESCRIÇÃO..., 2003).

Chart 5. Detailed information about the applications of eucalyptus species for different forestry sectors.

Applications of Eucalyptus species for different forestry sectors				
Species	Purposes			
	Energy	Paper and Cellulose	Civil Construction / treatment	Sawmill
I144	X	X	X	
H13	X	X	X	
Saligna 0020		X		X
Uro 110	X	X	X	X
Resinifera 0010	X		X	X
1277	X	X	X	X
Pellita	X		X	
Grandis AN 151	X	X		
Uro AN 189	X	X		
Torelliana	X		X	

Source: (DESCRIÇÃO..., 2003) adapted by the authors

LOCATION

The TUME (Test of Eucalyptus' Multiple Use) is located in Technical School *Prof. Dr. Antônio Eufrásio de Toledo*, which is by the margins of *Raposo Tavares* highway, km 561, in the municipality of *Presidente Prudente* – SP; the geographical coordinates of the area are 22°10'35.25''S and 51°22'36.60'', with altitude of 487m (GOOGLE EARTH, 2016).

Map 8. Panoramic photo of the TUM



Source: Google Earth 2016. adapted by the authors

The TUME arboretum was implemented during the month of April 2013 and, as all the 10 eucalyptus species cited were used, for each species were planted 05 lines, with 20 seedlings each, totaling 100 trees per species. The species used were: I144, H13, *E. saligna* 0020, Uro 110, *E. resinfera* 0010, 1277, *E. pellita*, *E. grandis* AN, Uro AN 189 and *E. tolleriana*.

During this period, climatic conditions showed no major changes compared to the decade average. The seedlings were donated by the Experimental Station of Forest Sciences of *Itatinga* / SP and belonged to the *Luiz de Queiroz* Agriculture College from the Sao Paulo University (ESALQ-USP). The planting was done with spacing of 3 x 2m for all species.

ASSESSMENTS

To analyze the profitability of each tree species implanted, we performed the measurement of the diameter at breast height (DAP) to 1.30 m from the ground, with the aid of forestry calipers; and the measuring of total height was made using the Haglöf digital clinometer, between the months of May and June 2016.

Data were processed in Excel spreadsheets, in which have converted, through formulas, diameter (cm) and height (m) in cubic cylindrical meters (m^3). Therefore, we could quantitatively evaluate the profitability of each species and their purpose.

RESULTS AND DISCUSSION

Among the thousand species planted in 2013, we had an 81% survival rate, totaling an amount of 813 units. This high death rate is not connected only to climatic conditions, but is related also with the food preference of existing capybaras in planted area, in particular the one of *E. Pellita*. Despite all the efforts, many samples were devoured by capybaras when the eucalyptus trees were still seedlings

Chart 6. Detailed information about the 10 species studied and their average height, diameter, survival rate and average of volume in m3

	Species	Average height	Average diameter	Survival	Vol. m³/existing	Total vol. m³ ha	Average vol. m³
1	**1277**	14.18	11.59	92	8.88	148.00	49.30
2	**I144**	12.14	11.25	98	6.356	105.90	35.30
3	**Grandis A N 151**	11.38	8.41	76	5.986	99.72	33.24
4	**H13**	10.52	9.22	89	4.87	81.12	27.04
5	**Uro 110**	8.71	7.90	73	4.35	72.45	24.15
6	**Uro A N 189**	8.86	8.36	78	4.321	69.00	23.00
7	**Resinifera 0010**	9.31	8.40	80	4.138	68.94	22.98
8	**Saligna 0020**	9.62	7.26	78	3.583	59.70	19.90
9	**E. pellita**	6.81	6.10	59	2.91	48.48	16.16
10	**E. torelliana**	8.07	8.26	90	2.7	44.98	14.90

Source: The authors

After analyzing the production capacity of each species, it was found the amount paid per cubic meter through the CEPEA index[6] of Marilia / Bauru region to the final product of pulp and paper and, in accordance with the IEA-APTA index[7], the prices January 2017 were the following:

Chart 7. Cubic meter prices

	Jan-17
Energy	41,32
Wood panel	41.15
Construction	57.63
sawmill	121.71
Pulp	25.00

Source: CEPEA adapted by the authors

To consider only the Average Annual Increment (IMA) of species and the impact of climatic and soil conditions of the region, it was not considered the mortality rate and therefore, the productivity per hectare although being of great importance, is not present in the table below. In it, we have species classification, their destination and the prices of January 2017.

[6] Index used by the University of Sao Paulo in a panel that monitors the agricultural prices of the market. Available at: http://cepea.esalq.usp.br/florestal/files/2015/01jan.pdf Accessed on 05 Jan.2017

[7] Official Index of the Secretary Agriculture and Food Supply of Sao Paulo State. Available at: http://www.iea.sp.gov.br/out/florestas.php Accessed on 05 Jan.2017

Chart 8. Detailed information about the species classification, their destination and the prices in January 2017.

	Species	Average volume m³	destination/revenues in Real R$									
			Energy		Wood panel		Construction		sawmill		Pulp	
1	1277	49,30	R$ 41,32	R$ 2.037,08	R$ 41,15	R$ 2.028,70	R$ 57,63	R$ 2.841,16	R$ 121,71	R$ 6.000,30	R$ 25,00	R$ 1.232,50
2	I144	35,30	R$ 41,32	R$ 1.458,60	R$ 41,15	R$ 1.452,60	R$ 57,63	R$ 2.034,34	//////	//////	R$ 25,00	R$ 882,50
3	Grandis A N 151	33,24	R$ 41,32	R$ 1.373,48	//////	//////	//////	//////	//////	//////	R$ 25,00	R$ 831,00
4	H13	27,04	R$ 41,32	R$ 1.117,29	R$ 41,15	R$ 1.112,70	R$ 57,63	R$ 1.558,32	//////	//////	R$ 25,00	R$ 676,00
5	Uro 110	24,15	R$ 41,32	R$ 997,88	R$ 41,15	R$ 993,77	R$ 57,63	R$ 1.391,76	R$ 121,71	R$ 2.939,30	R$ 25,00	R$ 603,75
6	Uro A N 189	23,00	R$ 41,32	R$ 950,36	//////	//////	//////	//////	//////	//////	R$ 25,00	R$ 575,00
7	Resinifera 0010	22,98	R$ 41,32	R$ 949,53	R$ 41,15	R$ 945,63	R$ 57,63	R$ 1.324,34	R$ 121,71	R$ 2.796,90	//////	//////
8	Saligna 0020	19,90	//////	//////	//////	//////	//////	//////	R$ 121,71	R$ 2.422,03	R$ 25,00	R$ 497,50
9	E. pellita	16,16	R$ 41,32	R$ 667,73	R$ 41,15	R$ 664,98	R$ 57,63	R$ 931,30	//////	//////	//////	//////
10	E. torelliana	14,90	R$ 41,32	R$ 615,67	R$ 41,15	R$ 613,14	R$ 57,63	R$ 858,69	//////	//////	//////	//////

The invoicing and the IMA are important indicators for farmers, but investors should also consider the initial investment, the security that each type of contract offers to his investment and the maintenance of each species. These items were not covered in this research.

In Brazil, eucalyptus trees take an average of seven years to reach the ideal moment for the first cut. This timeline may be too long for some investor's profiles, and thus the lower prices of the wood destined for pulp and paper may be more attractive since, in conformity with the contract clauses, some of them allow farmers to anticipate a partial sale or ensure the volume of sales.

This can improve the Internal Rate of Return (IRR) or, it could serve as an insurance for the large common volatility in the Brazilian economy. On the other hand, is very important to point out the basic interest rate of the Brazilian economy (SELIC) that should be considered.

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Recebido para publicação em 12/11/2017
Revisado em 09/12/2017
Aceito em 07/03/2018