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Evaluation of the standing timber potential in Pinus Caribaea plantations in Cuba

Evaluación del potencial de madera en pie en plantaciones de *Pinus Caribaea* en Cuba

Avaliação do potencial madeireiro em pé em plantações de Pinus Caribaea em Cuba

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ABSTRACT

To carry out this work, information was used from the database of the forest management project of the Empresa Agroforestal Macurijes, in 2018, in Pinar del Río. The study was carried out in 69 stands of Pinus caribaea plantations, corresponding to 6 plots of the Los Ocujes Silvicultural Unit, where the average diameter of the trees was 19.5 cm, the height 14.7 m and the average volume of the trees was 0.31 m3, the total volume of 151.21 m³ ha-1 and a total sampled area of 1,033.76 ha. With the objective of evaluating the potential of standing timber, the table of assortments in percentages (relative

volume) was used to determine what percentage of the wood evaluated corresponds to each specific assortment. The methodology was applied to estimate the real value and value standing market of the forest plantation, making penalties according to the age, quality and diameter class of the trees. The market value was adjusted to the real value based on parameters that define its potential for use and transport of the plantation product. The price levels proposed by the enterprise were applied to know the value of the forest.

Keywords: real value; market value; assortments; utilization potential and transportation.

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RESUMEN

Para la realización de este trabajo se utilizó información de la base de datos del proyecto de ordenación forestal de la Empresa Agroforestal Macurijes, en 2018, en Pinar del Río. El estudio se desarrolló en 69 rodales de plantaciones de *Pinus caribaea,* correspondientes a 6 lotes de la unidad silvícola Los Ocujes, donde el diámetro promedio de los árboles fue de 19,5 cm, la altura de 14,7 m y el volumen promedio de los árboles de 0,31 m^3, el volumen total de 151,21 m^3 ha^{-1} y un área total muestreada de 1.033,76 ha. Con el objetivo de evaluar el potencial de madera en pie se utilizó la tabla de surtidos en porcientos (volumen relativo), para determinar que porciento de la madera evaluada que corresponde a cada surtido específico. Se aplicó la metodología para estimar el valor real y valor de mercado en pie de la plantación forestal, realizando penalizaciones según la edad, la calidad y la clase diamétrica de los árboles. El valor de mercado se ajustó al valor real con base en parámetros que definen su potencial de aprovechamiento y transporte del producto de la plantación. Se aplicaron los niveles de precios propuestos por la empresa para conocer el valor del bosque.

Palabras clave: valor real; valor de mercado; surtidos; potencial de aprovechamiento y transporte.

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RESUMO

Para realizar este trabalho, foram utilizadas informações do banco de dados do projeto de manejo florestal da Empresa Agroflorestal Macurijes, em 2018, em Pinar del Río. O estudo foi realizado em 69 talhões de plantações de Pinus caribaea, correspondentes a 6 talhões da Unidade Silvicultural Los Ocujes, onde o diâmetro médio das árvores foi de 19,5 cm, a altura de 14,7 m e o volume médio das árvores foi de 0,31 m3, o volume total de 151,21 m^3 ha-1 e uma área total amostrada de 1.033,76 ha. Com o objetivo de avaliar o potencial da madeira em pé, foi utilizada a tabela de sortimentos em porcentagens (volume relativo) para determinar qual percentual da madeira avaliada corresponde a cada sortimento específico. A metodologia foi aplicada para estimar o valor real e o valor em pé mercado do plantio florestal, efetuando penalidades de acordo com a idade, qualidade e classe de diâmetro das árvores. O valor de mercado foi ajustado

ao valor real com base em parâmetros que definem seu potencial de uso e transporte do produto da lavoura. Os níveis de preços propostos pela empresa foram aplicados para saber o valor da floresta.

Palavras-chave: valor real; valor de mercado; sortimentos; potencial de utilização e transporte.

INTRODUCTION

To estimate the volume of standing trees, the classic formula and volumetric equations are commonly used tools, for which a forest inventory is previously carried out, generally by sampling (Orrillo, 2019). The forest inventory constitutes the fundamental part of forest management planning for the purposes of sustainable use and management, since it allows the potential of the forest resource to be determined qualitatively and quantitatively.

The management of plantations requires the conjunction of silvicultural, genetic and cultural aspects, which guarantee the maximum possible productivity at the lowest cost.

The volume is considered as an indicator variable of the potential or production capacity of a stand and is affected by different variables that must be considered in management, such as initial density, site quality, diameter, height, tree shape, the age of the plantation and silvicultural interventions (Martínez et al., 2022).

Due to the economic importance of the species *Pinus caribaea var. caribaea*, for the province and the country, commercial plantations are growing and the species is in forestry development plans. However, the surface area occupied by the natural forests of the species studied within Pinar del Río is increasingly smaller and on Isla de la Juventud they are greatly reduced due to the excessive use of their wood (Valdés, Alvarez & Fernández, 2021).

It is well known that over the years the tree begins the formation of adult wood, the appearance of heartwood also begins; the wood characteristics of planted trees vary as the individual matures. These factors are key in the quality and price of commercial wood. At what age do these changes occur in the tree? is a question with different answers depending on the species (Murillo et al., 2004).

With the real value of the standing plantation, it is essential to analyze the possibilities of being able to take advantage of and transport that product to its transformation site. It is of vital importance to designate the most suitable and least remote sites within the area to be used, with the aim of avoiding a considerable increase in the costs of management and harnessing of the plantation, since these additional costs must be considered when of

valuing a forest plantation (Vergara et al., 2013).

The standing commercial value of the plantation is based on the real value of the standing plantation adjusted by the potential for use and transportation of the wood to its nearest processing site. A forest plantation could present excellent volumetric, qualitative and age characteristics (real standing value), however, its location within the lot, access to the lot and other conditions could cause its commercial value to decrease significantly (Murillo et al., 2004).

This decrease in the value of the plantation could reach the extreme point of determining that it reduces its commercial value by 50%. However, it is important to emphasize that in this work we only intend to deal with the estimation of the value of standing timber, without yet considering a detailed analysis of the harnessing and transportation costs.

The objective is defined to evaluate the potential of standing wood; which is a vital element for efficient management, because knowing the timber value will allow it to be valued on a scale of importance, from the optimal point of view of social well-being (Requejo et al., 2022).

MATERIALS AND METHODS

The Empresa Agroforestal Macurijes is located in the westernmost region of the province of Pinar del Río, covering parts of the territories of the Guane and Mantua municipalities (Valdés et al., 2021). It limits to the Northeast with the Minas de Matahambre municipality (Empresa Agroforestal Minas de Matahambre) and with the coastal coast from Ensenada de Baja to Ensenada de Garnacha; to the East with the San Juan y Martínez municipality (Empresa Agroforestal Pinar del Río); to the South with the Sandino municipality (Empresa Agroforestal Guanahacabibes) and to the Southeast with the coast of the Gulf of Mexico between the mouths of the Cuyaguateje and Puercos rivers (Figure 1).

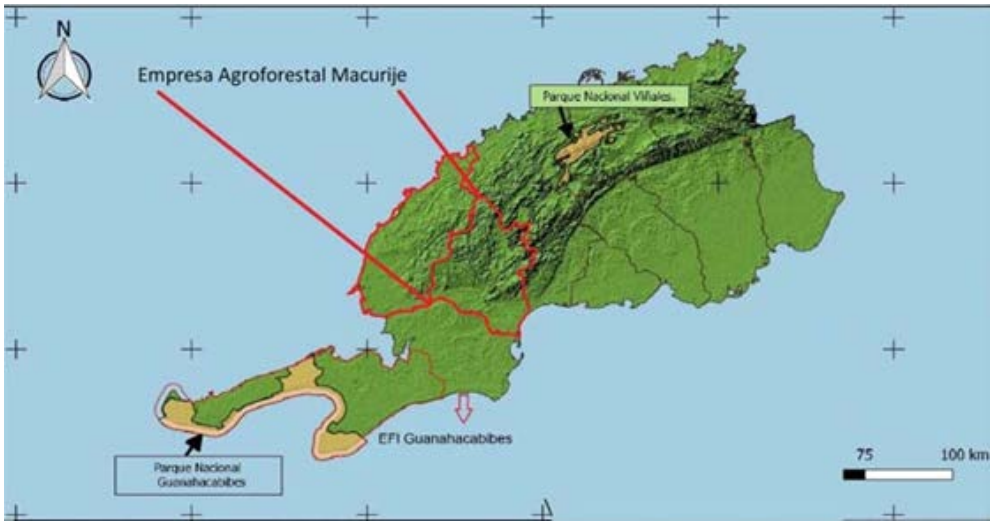

Figure 1. Geographic location of the Empresa Agroforestal Macurije.
Source: Rodríguez et al. (2020).

Methodologically, the research is supported by the definition of the volume of standing wood from a sampling or inventory, and estimation of the value from the methodology based on the real value and market value proposed by Murillo et al. (2004) cited in Gutiérrez et al. (2022).

As a dependent variable, the value of the standing forest plantation was counted, and as independent variables, it was worked with the dimensions of the trees, the volume, price of wood, age of the plantation, quality of the wood, criteria of its potential. of use and transportation. It was also worked with the nomenclator of assortments and wood species.

Works in plantation of pilon carried out by Murillo et al. (2004) were analyzed and studied (*Hieronyma alchorneoides*) in the Sarapiquí area, Heredia, Costa Rica. (2004), as well as valuation studies of Tectona grandis Linn plantations in the department of Córdoba, Colombia, by Vergara et al. (2013), and studies carried out in Eucalyptus globulus Labill plantations, distributed in four annexes of the Daniel Hernández district, belonging to the Pampas Tayacaja province in Peru, by Gutiérrez et al. (2022).

Starting from the information derived from the inventory to the previously selected area, the general characteristics (total area, number of plots, area of a plot and shape factor or coefficient) and the specific characteristics (diametric class, number of trees per class) and average commercial height) were obtained. Using a volume table or information from the sampled area, the volume of each tree, volume per plot, volume per hectare and the total volume of the area to be harvested were calculated. All this information collected was part of the database of the forest management project of the Empresa Agroforestal Macurije, in 2018.

The study was completed with the measurement of each of the trees of the

following variables: straightness of the trunk, presence of bifurcations, presence of reiterations, presence of spiral grain, presence of shrimps, inclination of the trunk, phytosanitary status and the general variables. Of quality of the complete tree, as well as the criteria related to the potential for use and transportation.

The study was carried out in 69 stands of *Pinus caribaea* plantations, corresponding to 6 lots (Figure 2), of the Unidad silvícola Los Ocujes, where the average diameter of the trees was 19.5 cm, the height was 14.7 m and the average volume of the trees of 0.31 m3, the total volume of 151.21 m³/ha and a total sampled area of 1,033.76 ha.

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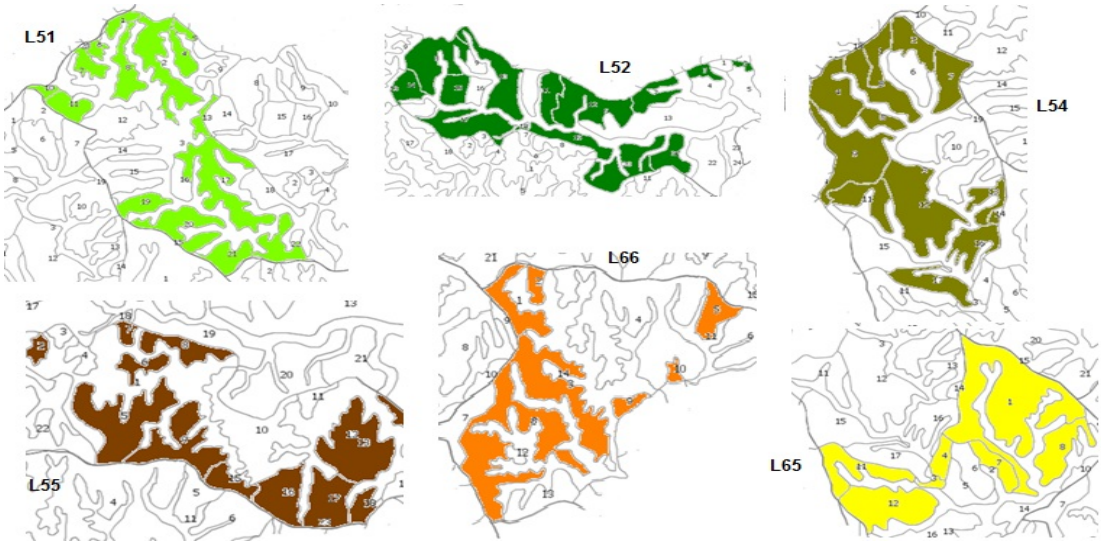

Figure 2. Distribution of 69 stands corresponding to 6 sampled lots.
Source: Empresa Agroforestal Macurijes management project (2018).

With the development of the standing evaluation methodology of the quality of forest plantations (Murillo et al., 2004), cited in Vergara et al. (2013) and by Gutierrez et al. (2022), a great possibility opens up to achieve a better estimate of the real value based, not only on the volume and dimensions of the trees, but also on their commercial wood production potential.

Once we have the volume, we define the volume of wood per assortment, for which we used the information contained in tables designed for this purpose, such as the one proposed by Ares (1999) cited in Castillo (2016) and Ndjamba et al. (2021), as reflected in Table 1.

Each tree, according to its diameter class, has a percentage of wood that corresponds to a type of assortment. Depending on the demands of the market or the industry, the trunk of the trees can be used for logs destined for the sawmill industry (class A, B, C roundwood and low-dimensional roundwood), it can be sold as roundwood. for various uses, for firewood, among other options.

Table1. Assortment table in percent (relative volume) *Pinus caribaea*. **Source:** Ares (1999).

$D_{1.30}$ (cm)	V (+24 cm)	V (13-24 cm)	V (6-13 cm)	V (< 6 cm)
8	0,00	0,00	86,69	13,31
10	0,00	20,17	72,16	7,67
12	0,00	47,39	47,71	4,90
14	0,00	63,42	33,23	3,35
16	0,00	72,94	24,63	2,43
18	0,00	79,13	19,03	1,84
20	0,00	83,32	15,25	1,43
22	14,13	72,12	12,60	1,15
24	27,16	61,21	10,69	0,94
26	36,95	53,00	9,26	0,79
28	44,27	46,86	8,19	0,68
30	48,90	43,16	7,35	0,59
32	51,14	41,28	7,03	0,55
34	56,74	36,56	6,23	0,47
36	59,37	34,35	5,85	0,43
38	61,35	32,68	5,57	0,40
40	62,79	31,47	5,36	0,38
42	63,77	30,65	5,22	0,36
44	64,32	30,19	5,14	0,35
46	64,42	30,10	5,13	0,35
48	64,75	29,82	5,08	0,35
50	65,72	29,01	4,94	0,33
52	66,63	28,24	4,81	0,32

Each type of assortment has a given price and it is very important to be able to make a good classification to be able to sell at the best prices. To estimate the potential of standing wood, the price table proposed by the enterprise was applied to the volumes obtained, and the income from the sale of sawn wood Classes A, B and C, roundwood and firewood were considered.

For the calculations, the equations were helped 1, 2 y 3.

- Frequency (sum of all trees counted by diameter class, divided by the number of plots).

$$\text{DC Frequency} = \frac{\Sigma \text{ of all counted trees of that Diameter Class}}{\text{Number of plots analyzed}} \quad [1]$$

- Tree volume: $V(tree) = \frac{\pi}{4} * D^2 * \text{Height} * \text{Form factor}$ [2]
- Diametric Class Volume: $V(cd) = V(tree) * Frequency$ [3]

The national market differentiates prices according to the species and assortments. This price estimate was the starting point in the valuation of the standing plantation.

The research was based on the methodology proposed by Murillo et al. (2004), to be able to make the assessment of a forest plantation. Firstly, adjust the so-called Real Value, which basically consists of determining the standing commercial volume and making penalties according to the age, quality and dimensions of the tree.

Once the actual standing value was determined, an analysis called Market Value continued, for which seven criteria related to harnessing and transportation potential were reviewed, including: plantation size, topography/slope, access to plantation, presence of rocks in the terrain, density of the plantation, presence of weeds and distance to the transformation site. The value of the standing timber then undergoes a new adjustment based on the effect of each revised parameter.

- ✓ Adjustment of the value according to the age of the tree.

The wood market tends to pay a better price for adult wood with heartwood than for juvenile wood with sapwood (Murillo et al., 2004). In work with conifers and other species it has been found that, for a large number of forest species, the tree begins the transition towards the formation of adult wood at 7-10 years. Therefore, 10 years was taken as the reference age, after which the real value does not change (adjustment value 1.0), but decreases for younger ages (adjustment value 0.8). Some authors such as Gutiérrez et al. (2022), considered 8 years as the reference age to make the adjustment based on age.

- ✓ Adjustment of the value according to the quality of the tree**.**

It is very possible that the Cuban wood market has not yet clearly defined the payment of a better price according to the quality of the wood, the truth is that defects in the log do have a direct impact on the primary industry of wood transformation. Straight pieces, free of knots and little taper, undoubtedly have a higher transformation percentage than pieces with defects.

To assess the quality of the tree, scales were taken that range from the completely straight or slightly twisted tree (adjustment value 1.0), to the non-sawable log that is exclusively useful for firewood, round poles or biomass (adjustment value 0.4), taking into account qualitative variables such as: bifurcation, spiral grain, inclination, mechanical damage, phytosanitary status, among others. Gutierrez et al. (2022), considered in their work three quality scales instead of four.

- ✓ Adjustment of the value according to the dimensions of the tree**.**

It was estimated that market prices for standing timber from plantations are based on logs of just over 25 cm in diameter. Therefore, this was the log diameter that was used as a discount

reference. The adjustment was in function of how the price of wood is estimated according to the species. Adjustment of the value according to the potential for use and transportation.

The other adjustment was made taking into account that, with the real value of the standing plantation, it is essential to analyze the real possibilities of being able to use and transport that product to its transformation site. The standing commercial value of the plantation will also be based on the real value of the standing plantation adjusted by the potential for use and transportation of the wood to its nearest processing site.

According to the reviewed bibliography (Murillo et al., 2004), it has been determined that the most important criteria in determining the costs of harnessing and transporting wood from forest plantations are: scale of operations, access within the lot or stand, distance to industry, topography and slope, plantation density, weeds and rockiness. Therefore, the potential would be as shown in equation 4.

Market value = Real value * (Use and transportation potential) [4]

Regarding the scale of operations, the size of the plantation will decisively influence its value due to its effect on management and utilization costs. The larger the production scale, the lower the utilization costs. The percentages of the real value range between 60 and 100%.

Undoubtedly, access to the plantation within the stand or lot is one of the criteria that significantly influence the cost of harnessing. Here, plantations with year-round access with light vehicles to the very edge, to those that require large earthworks and opening of roads over a distance greater than 1 km, were taken into account. Three types of access are defined that affect the real value between 30, 45 and 100% respectively.

The distance to the wood processing industry significantly affects the costs and transportation strategy required. Three levels of distance were defined that affect the real value by 60, 80 and 100 % respectively.

Excessive stoniness in a plantation causes many trees to break during harnessing, which affects the loss of the economic value of these individuals. This criterion is, however, of lesser weight in the total assessment of the plantation. Here, everything was considered from zero stoniness (100% of the actual value) to terrain with large rocky outcrops that could cause mechanical damage or breakage to the cut trees (85 % of the actual value).

Plantations with a high density of individuals per hectare considerably increase harnessing costs and yields. Two valuations were proposed, those plantations with less than 500 trees per hectare (100 % of the real value), and those plantations with more than 500

trees per hectare (85 % of the real value).

Plantations with *excessive weeds* do not allow quick and efficient use. The workers have to invest time in cleaning each of the trees to be felled. It was taken into account, when the weeds of the land do not impede the use in a significant way (100% of the real value), even when it is necessary to do cleaning work to be able to use it (85% of the real value).

The criterion on topography and slope: it is perhaps one of the criteria that has the greatest influence on the costs and strategy of using forest plantations. Three levels of slope were considered: 0–15 % (100 % of the actual value), or long hills with the absence of many obstacles; 15-30 % (65 % of actual value) or short, steep hills; greater than 30 % (30 % of the real value).

The last step was the determination of the market value: this value seeks to adjust the real standing value to the objective conditions of use and transportation of the wood from the plantation. The final equation for the market value of the plantation corresponds to equation 5.

Commercial Value = (Real Value) * ([1] *0,15 + [2] *0,15 + [3]*0,2 + [4]*0,05 + [5]*0,10 + [6]*0,05 + [7]*0,3))[5]

The criteria that qualify the potential for use and transportation do not have the same weight in the global equation. A distribution of the weight of each criterion was proposed, based on the experience proposed by Murillo et al. (2004).

If a plantation received the worst rating in the 7 criteria of harnessing and transportation potential, the market value would reduce the real standing value by up to 50%. In this type of situation, decisions are made about the future of the plantation. It could be analyzed which of the 7 criteria of harnessing and transportation potential could be improved over time: access, weeds, density and scale of operations.

With this valuation model it is possible to determine precisely where resources should be invested to increase the standing commercial value of a forest plantation.

RESULTS AND DISCUSSION

The results obtained per lot, from the entire area analyzed, are presented in Table 2. For the assessment of the standing timber potential, the prices of sawn timber, roundwood and firewood were considered.

It was worked with the information corresponding to Lot 52, considering that it is the lot with the largest volume and largest area. It is common to take into account that, of the total volume calculated from an inventory,

approximately 90% is usable, and that the other 10 % is considered biomass or foliage, in addition to frequently defining parent trees per hectare, which are not cut down to stimulate natural regeneration in the area.

On the other hand, the performance in the sawmill depends on the technology available, so the performance will not be 100% of the analyzed volume of the standing wood.

Table 2. Volumes by assortment of the entire analyzed sample. **Source:** Own elaboration.

Lot	Wood in Bolo (m^3)	Wood in Bolo BD (m^3)	Plump (m^3)	Others (m^3)
51	178,43	9.687,06	4.534,71	457,60
52	14.556,92	42.450,25	8.517,66	779,97
54	9.914,43	9.159,47	3.037,72	280,68
55	293,78	5.201,43	4.098,03	482,06
65	3.399,70	11.487,38	4.252,26	415,56
66	6.796,32	12.669,65	2.450,54	217,49
Sub-Totals	**35.139,58**	**90.655,24**	**26.890,92**	**2.633,36**
	Total		**155.319,10**	

The values obtained in Table 2 are the result of the application of the assortment table (Table 1) and are based on logs, so biomass is not considered.

Income from the sale of sawn wood Classes A, B and C, low-dimensional log wood, round wood and firewood were considered.

Table 3 shows the results related to the possible income to be obtained from the sale of the wood from Lot 52. It is known that, to obtain 1 cubic meter of sawn wood, approximately 2 meters of bolus wood (logs) are needed. 1), so it is considered that the yield of bolus wood will be 50 %. Of that 50 %, 65 % is allocated for class A sawn lumber, 10 % for class B sawn lumber and 25 % for class C sawn lumber. Likewise, only 33 % of the wood yield is considered in bulk. low dimension (logs 2). As roundwood is not sold as a finished product, the 8,517.66 m^3 obtained from the analysis are sold**.**

The 50 % yield of the 14,556.92 m^3 of the bolus wood volume (Table 3) corresponds to 7,278.46 m^3. In the case of sawn wood, class A, the 4,731.00 m^3 volume is obtained by calculating 65 % to 7,278.46 m^3, estimated for this class. Similarly, the 727.85 m^3 of class B sawn wood constitute 10 % of 7,278.46, and the 1,819.62 m^3 of class C sawn wood also constitute 25 % of said figure.

The 33 % yield of the 42,450.25 m^3 of the volume of wood in bolus BD (Table 3) corresponds to 14,008.58 m^3. In the case of firewood, 779.97 m^3 are considered.

Adjustments to the real value were made, according to the methodology for estimating the value of standing forest plantations, based on the real and market value, proposed by Murillo et al. (2004).

Table 3. Income from the sale of wood from Lot 52**. Source**: Own elaboration.

Producto	Volume (m^3)	Sales Income ($)
Class A Sawn Lumber	4.731,00	9.535.803,44
Class B Sawn Lumber	727,85	944.620,56
Class C Sawn Lumber	1.819,62	1.694.644,17
Low Dimension bolo wood	14.008,58	15.409.439,20
Round Wood	8.517,66	8.046.120,26
Firewood	779,97	155.994,72
Total:		**35.786.622,37**

It was considered not to use the age criterion, since a plantation that is very close to its cutting cycle or in its cutting cycle was evaluated, so it is assumed that there is the presence of adult wood. This is demonstrated by the fact that the average age values of the individuals in the stands of Lot 52 ranged between 14 and 46 years, with an average age in the lot of 36.4 years, that is, greater than 10 years, so, the actual value does not need to be adjusted.

A decrease in this value would have occurred if the average age of the plantation had been less than 10 years, which translates into a high proportion of sapwood in the wood at early ages and, in most cases, it would not have been carried out. to the plantation its first thinning. Gutierrez et al. (2022) considered 8 years as a reference.

Therefore, in this work, the initial value of $ 35.786.622,37.

Table 4 shows the adjustment according to dimensions or by diameter class, for Lot 52. It was based on the income from the sale of wood, with an initial value of $ 35.786.622,37**.**

The diameter used as a discount reference was 25 cm. Those individuals with diameters less than 25 cm were adjusted in their value with a discount of -10 %, -27 % and -52 %, for the pieces that were located within the diameter classes of 20 (17.51-22. 5 cm) 15 (12.51-17.5 cm) and 10 (<12.51 cm), respectively.

Table 4. Adjustment of the real value according to the dimensions, for Lot 52. **Source:** Own elaboration.

CD(cm)	Interval	Adjusting Value	Value	Adjusted value
10	X < 12,5 cm	0,48	135.094,72	64.845,47
12	X < 12,5 cm	0,48	718.092,51	344.684,40
16	12,5 cm ≤ X < 17,5 cm	0,73	744.554,89	543.525,07
18	17,5 cm ≤ x < 22,5 cm	0,9	2.701.883,97	2.431.695,57
20	17,5 cm ≤ x < 22,5 cm	0,9	3.731.786,52	3.358.607,87
22	17,5 cm ≤ x < 22,5 cm	0,9	11.117.185,02	10.005.466,52
26	22,5 cm ≤ x < 27,5 cm	1	5.308.399,13	5.308.399,13
28	22,5 cm ≤ x < 27,5 cm	1	11.329.,625,61	11.329.625,61
Totals			**35.786.622,37**	**33.386.849,64**

Likewise, individuals with diameters between 22.5 and 27.5 cm maintained their value, and no individuals were found located in diameter classes above 27.5 cm, so it was not necessary to adjust the value. The real standing value of the plantation is then obtained, based on the sum of all the values generated. The new adjusted value is $33,386,849.64, which decreased by 6.71 % with respect to the initial value, which was not high because the volume of low-dimensional wood was lower, in which the adjustment value is low, with respect to the volume of wood of above average dimensions. However, no dimensions were found for which the adjustment value exceeded unity.

This result differs from that obtained by Gutiérrez et al. (2022), since in their sample, the diameter at chest height of 40.3% of the individuals ranged between 30 and 40 cm, for which the adjustment value would be above unity.

The results obtained, after adjusting the value assigned to the wood, according to its quality category, are shown in Table 5.

The real standing value of the plantation was then obtained, based on the sum of all the values generated. The new adjusted value is $28,712,690.69, which decreased by 19.77 % with respect to the initial value, and by 14 % with respect to the adjusted value after making the adjustment according to the dimensions.

Table 5. Adjusted distribution of real standing value according to quality category **Source:** Own elaboration.

CD (cm)	Quality 1 (1,0)	Quality 2 (0,9)	Quality 3 (0,8)	Quality 4 (0,4)	Total
10	22.695,91	17.508,28	12.969,09	2.593,82	55.767,10
12	120.639,54	93.064,79	68.936,88	13.787,38	296.428,59
16	190.233,77	146.751,77	108.705,01	21.741,00	467.431,56
18	851.093,45	656.557,80	486.339,11	97.,267,82	2.091.258,19
20	1.175.512,75	906.824,12	671.721,57	134.344,31	2.888.402,77
22	3.501.913,28	2.701.475,96	2.001.093,30	400.218,66	8.604.701,21
26	1.857.939,70	1.433.267,77	1.061.679,83	212.335,97	4.565.223,25
28	3.965.368,96	3.058.998,91	2.265.925,12	453.185,02	9.743.478,02
	11.685.397,37	**9.014.449,40**	**6.677.369,93**	**1.335.473,99**	**28.712.690,69**

For Gutiérrez et al. (2022), of the total number of individuals evaluated, the quality of stem 2 was the one that reported the highest percentage of individuals, with 74.0 %; while, for the sample analyzed in this work, the quality of stem 1 reported the highest percentage with 40.70 % of the adjusted value (20.8 % for Gutiérrez et al., 2022), seconded by the quality of stem 2 with 31.40 %, the quality of stem 3 with 23.26 % (5.2 % for Gutiérrez et al., 2022), and 4.65 % the quality of stem 4, a scale that was not considered by Gutiérrez et al. (2022).

The result of the analysis of the criteria related to the potential for use and transportation of the analyzed sample is presented in Table 6, in which a distribution by weight and qualification of each of the criteria that determine that potential is made.

Table 6. Weight distribution and qualification by criteria. **Source:** Own elaboration.

Evaluation criteria	Weight in the global equation (%)	Rating of each of the criteria	Weight rating (%)
[1] Scale of operations	15	100	15
[2] Access to the plantation	15	65	9.75
[3] Distance to transformation site	20	100	20
[4] Stonyness	5	100	5
[5] Planting density	10	100	10
[6] Presence of weeds	5	85	4.25
[7] Topography and slope	30	100	30
Total	**100 %**		**94 %**

The study was carried out in an area of 1,033.76 ha, of which 259.90 ha correspond to Lot 52, which means that the size of the plantation is greater than 20 ha, which allows it to be placed on a scale of 3.

To access the stands belonging to Lot 52, light road conditioning work is required in a distance of less than 1 km,

which is why scale 2 corresponds to it. The wood processing site (sawmill) is located less than 25 km from the place where the harnessing takes place, which qualifies it as scale 1. However, the possibility that the wood is transported to another, more distant center within the region or province could be analyzed. The stoniness of the terrain is practically non-existent or scarce, which prevents causing mechanical damage or breaks to the cut trees, scale 1.

The study area has less than 500 trees per hectare, which means there is no considerable increase in harnessing costs and yields. In the studied area there is a presence of weeds, although not significant, but cleaning tasks need to be carried out to be able to use them, which is why it is considered scale 2.

Finally, an analysis of the topography and slope revealed results from 11 % to 22 % in the stands corresponding to Lot 52, although there were very few stands with a slope above 15 % (3 stands), which makes assess the criterion as scale 1.

By substituting into equation 5, the following result will be obtained:

Commercial Value = (28.712.690,69) * ([100] *0,15 + [65] *0,15 + [100]*0,2 + [100]*0,05 + [100]*0,10 + [85] * 0,05 + [100] * 0,3))

Commercial Value = (28.712.690,69 * 0,94) = $ 26.989.929,25

Difference from initial value: $ 8.796.693,12

The real standing value of the plantation of Lot 52 then decreased, from a real value of $28,712,690.69 to a commercial value of $26,989,929.25, which is equivalent to a decrease of 6% (Table 6), corresponding to $1,722,761.44, and a decrease with respect to the initial value, of $8,796,693.12**.**

With the result of this valuation work, based on the real and market value, it is possible to determine where to invest the resources to increase the commercial value of the plantations, which undoubtedly brings great benefits to the sector.

According to Murillo et al. (2004), it can be noted that the proposed procedure to determine the value of a forest plantation is simple and objective. The contribution of a methodology of this type is of great value for the development of a new professional field, the appraisal and assessment of forest plantations. Boom in plantation-level transactions could be significantly improved.

The authors of this research, coinciding with Gutiérrez et al. (2022) and Vergara et al. (2013), consider that the criteria related to the potential for use and transportation can be used with even more drastic reductions or adjustments, up to a minimum percentage value of 40% for the worst of the qualifications.

CONCLUSIONS

The wood potential of a lot of 66,304.80 m3 of the *Pinus caribaea* species was evaluated, which reported an initial value of $35,786,622.37 according to wood assortments and prices.

The initial value was adjusted according to the methodology of the real value and market value for forest plantations, which allows determining where to invest the resources to increase their commercial value, which undoubtedly brings great benefits to the sector. The adjusted value was of $ 26.989.929,25.

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AUTHORS' CONTRIBUTION

Martínez Cantón, J.L.: bibliographic review, article writing, article calculation and adjustment.

Alvarez Lazo, D.: methodology, bibliographic review, content review, advice and final review.

Fernández Concepción, R.R.: methodological review, advice.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.