QUALITY CONTROL OF LOGS IN SEMI-MECHANIZED HARVEST

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Resumo

Controle de qualidade do seccionamento de toras. Na colheita semimecanizada de madeira, o seccionamento de toras deve ser realizado com qualidade para obtenção de toras com dimensões padrões. Evita o desperdício e atende à demanda dos clientes, sendo fundamental a gestão e monitoramento da execução dessa atividade. O objetivo deste estudo foi elaborar e testar *in loco* um método de controle da assertividade dos comprimentos de toras seccionadas de maneira semimecanizada. A aplicação do método foi realizada em povoamento de *Eucalyptus* sp. com ciclo de manejo florestal de 20 anos. O levantamento foi dividido em cinco planos de ação (PQ0, PQ1, PQ2, PQ3 e PQ4) com leituras quinzenais. Sendo que PQ0 para reconhecimento do cenário; e, PQ1 a PQ4 aplicação dos planos de ação, mensuração das toras e classificação quanto aos níveis (correto, aceitável, preocupante, crítico e inaceitável). Utilizou-se o teste "t" de proporção de médias para mostrar diferenças. Percebeu-se que houve melhoria nos percentuais de nível correto e aceitável, na primeira quinzena. O método de controle mostrou minimizar falhas e desperdícios. Constatou-se que após a aplicação do método foi possível evitar a perda de 0,73% do volume total de madeira colhida e processada.
Palavras-chave: Desperdício de madeira; Fatores de qualidade; Procedimento operacional.

Abstract

Qualitative logging must be carried out on the semi-mechanized harvest to result in correct logs for the standard measures. This avoids waste and meets the demand of the clients, so management and monitoring of the execution of the logging activity are paramount. The objective of this study was to develop and test *in loco* a method to control the assertiveness of the lengths of logs, sectioned in a semi-mechanized manner. The method was applied in a stand of *Eucalyptus* sp., with a 20- year forest management cycle. The survey was divided into four action plans, with biweekly (PQ0, PQ1, PQ2, PQ3 e PQ4) monitoring of activities where PQ0 was for scenario recognition, and PQ1 to PQ4 were for the application of actions and measurement of logs and the classification according to levels (correct, acceptable, alarming, critical and unacceptable). It was observed the improvement of the percentages of the correct and acceptable levels, already in the first fortnight. The control method aided in minimizing failures and waste. It was found that after the application of the method avoided the loss of 0.73% of the total volume of the harvested and processed wood.
Keywords: Operational routine; Quality factors; Wood waste method.

INTRODUCTION

Semi-mechanized harvesting operations are rustic activities and require quality management and defined and structured planning to optimize resources. Serpe *et al*. (2018) point out that the waste that occurs during forest harvesting needs to be measured. Vatraz and Borges (2014) state that incorrect information on the volumetric estimate of wood may harm the managerial results.

Lachtermacher (2009) explains that decision-making results from the identification of a problem or opportunities, and the actions are chosen to solve them. The author highlights the factors that can affect decision-making: a) available time; b) importance of the decision; c) the environment; d) certainty or uncertainty and risk; e) decision-making agents; f) conflicts of interest. For the authors Corrêa and Corrêa (2017), the main objective of planning and management is to maximize the chances of success, taking into account the company's mission and values, as well as the implementation of tools, concepts, and experiences acquired over time. Thus, it can be inferred that the achievement of good operating and production results is the result of how everything is planned and managed.

Sousa (2020) reports that the use of a continuous improvement tool in a company will change in the technical aspect as well as in the behavioral one, which will result in learning and possibly in the consolidation of the planning, management, and control system. According to Campos (1992), quality control has three objectives: a) plan the quality of its product based on the customers' needs; b) control the quality (if necessary, preventive and corrective measures should be applied); c) to predict constant improvement, based on the needs of its customers.

Serpe *et al*. (2018) infer that decision-making in the forestry sector requires quantitative and qualitative information and that the losses caused by forest harvesting activities are often disregarded, may be greater or lesser depending on the quality of the stand and operations related to forest harvest. Foelkel (2007) points out that wood losses, observed at harvest, can occur in the form of high stumps, stem tips below the pre-established diameter, cracked and unduly lost (forgotten) logs in the field, sawdust generated in the felling of the tree and sectioning of logs into improper dimensions.

In semi-mechanized cutting, most of the movements performed by the chainsaw operator are repetitive, generating, in some cases, non-uniform actions, which demand monitoring and readjustments. Trindade *et al*. (2017) state that for improving such a process, it is not only necessary technology or large instrumental apparatus but the goodwill and attention of the operators is essential.

For forestry operations that use chainsaws, Fernandes and Berton (2012) highlight the need to develop a plan to control, measure, and evaluate the actions performed. Campos (1992) states that the operator must participate with suggestions to aid in the continuous evolution of quality. Also, Sousa (2020) corroborates that the changes affect the technical and behavioral level and contribute to production, with an increase in the productivity of the teams, allowing the identification and correction of deviations from the goals. Jacovine *et al*. (1999) point out that improving the quality of the operational process and reducing costs are necessities. They also complement that the forestry sector demands to rethink and restructure the processes.

According to Baumgardner (2012), research can be advantageous in several situations, but to execute the decision is not automatic, it includes the analysis of costs and benefits, available resources to execute it, and to implement it. Trindade *et al*. (2017) state that studies involving the quality of operations are increasing in the forestry sector and that there are still many challenges to be met, especially in the development of methods to compose the evaluations and to monitor the advances. They also state that there is an effort and that there are always compensatory gains. In order to improve quality control procedures in the semi-mechanized operation of sectioning trees into logs, in the field, a method was developed and tested, in loco, to control wood waste.

MATERIAL AND METHODS

The study was carried out in cooperation with a forestry company that produces *Eucalyptus* sp. logs, with a management cycle of 20 years, in the municipality of Butiá, state of Rio Grande Do Sul. The assortments extracted from these forests are 550-600 cm logs (minimum diameter of the fine tip of 24.0 cm), logs with lengths ranging from 550 to 600 cm (diameter of the fine tip of 18.0 cm to 24.0 cm), short logs with 300 cm in length (fine tip diameter from 18.0 cm to 24.0 cm) and process wood (below 18.0 cm in diameter). The forest is produced focusing on obtaining wood with greater density and quality for splitting, for use in the furniture industry and civil construction. In the harvesting process, after the tree is felled, the logs are sectioned, still inside the stand. This process did not follow a standard operating procedure, and quality assessments were performed by measuring the logs using a wooden ruler (a cut branch). In this measurement method, adopted by the company, an additional of 10 cm was granted in the length of each log, a requirement of the customers to carry out the topping with the removal of possible cracks.

After a pilot evaluation of the method used until then, the initial demands were prepared and presented to the manager, to understand the scenario of the measurement quality of the log to be delivered to the customers. Based on this understanding, a quality scale was created (Figure 1) with levels of satisfaction according to the criteria listed by the forestry company, considering the desired length and increases/decreases of 5.0 cm. Also in this method, the addition of 10 cm was maintained in the standard measurements so the buyer would carry out the topping and the removal of possible cracks. The levels of satisfaction in relation to the length of the logs were described and can be seen on the scale in Figure 1, as follows: 1- Correct: exact cutting measurement; 2- Acceptable: it does not result in losses for the buyer nor the company; 3- Alarming: results in a loss for the company due to the excess of wood volume, but does not result in a loss for the buyer; 4- Critical: with a length above (high volume loss for the company) or below the measurement (customer will receive a log beyond the desired minimum standard); 5- Unacceptable: high degree of losses (great waste of wood for the company or beyond the standard for the customers).

Length of the logs 5.50 m

5.40	5.45	5.50	5.55	5.60	5.65	5.70	5.75	5.80	5.85	5.90	5.95
5.00	5.00	5.00	4.00	1.00	2.00	3.00	4.00	5.00	5.00	5.00	5.00

Length of the logs 6.00 m

5.90	5.95	6.00	6.05	6.10	6.15	6.20	6.25	6.30	6.35	6.40	6.45
5.00	5.00	5.00	4.00	1.00	2.00	3.00	4.00	5.00	5.00	5.00	5.00

Escala

1.00	Correct
2.00	Acceptable
3.00	Alarming
4.00	Critical
5.00	Unacceptable

Figure 1. Structure of the quality scale in levels for the assessment of wood waste in logging, where: X) target measure; 1) Correct; 2) Acceptable; 3) Alarming; 4) Critical; 5) Unacceptable.

Figura 1. Estrutura da escala em níveis de qualidade para a avaliação do desperdício de madeira, no seccionamento das toras, onde: X) Medida almejada; 1) Correta; 2) Aceitável; 3) Preocupante; 4) Crítica; 5) Inaceitável.

To validate the quality scale, a scenario analysis was conducted over 15 days of operation, with five random days for data collection. Simple random sampling was carried out, measuring the length (cm) of the logs and diameter of the fine tip (cm), arranged in piles on the side of the road or inside the stands. To carry out this survey, the following were used: PPE's, tape measure, and dendrometric suta. The Zero Fortnightly Plan (PQ0) aimed to identify the situation in which the assertiveness of the length of the logs was found. Once non-conformities were found in the standardization of length, a goal was defined according to the levels of satisfaction, in each following fortnight of evaluation, where: 60% correct; 30% acceptable; 5% worrying; critical and unacceptable, both at 2.5%. The sampling sufficiency of logs was obtained through Equation 1 (PÉLICO NETO; BRENA, 1997).

$$n = N.S^2.t^2 \, / \, N.(E.\bar{X})^2 + S^2.t^2$$

where: n = number of plots; N = total number of likely plots; S^2 = variance of the evaluated parameter; E = admissible error; ; $\bar{X}$= mean of the evaluated parameter; t = probability distribution value.

After PQ0 analysis, the four treatments were defined, each corresponding to an action plan, lasting 15 days. Each action plan was structured together with the operational sector, implemented with the field team and the quality assessments were carried out to monitor the evolution of the operation's assertiveness.

In the first action plan, the project was presented to the chainsaw operator and the assistant, to clarify doubts and encourage adherence to the project, avoiding communication noise. This action was repeated during the implementation of the other action plans.

In PQ2, to make the measurement less rudimentary, the ruler was demarcated with red and yellow colored adhesive tape. The operator was instructed to use a color for each measurement provided in the log cutting plan. In PQ3 and PQ4, the monitoring and improvement of the applications of the first and second improvement actions were carried out with the measurement of the logs in loco.

After collecting the data, they were tabulated in a spreadsheet and the "T-test of the central limit theorem proportion was performed, with the aid of the Excel-Action Stat extension statistical tool. In this test, $\bar{X}$ will have an approximately normal distribution, with mean "p" and (p (1-p))/n variance. The values were obtained through Equation 2. In the first analysis, PQ0 was compared with the other plans, always guided by the goal stipulated by the company. In the second analysis, all levels of a fortnight ("x") were compared with the same levels of the previous fortnight ("x-1").

$$z = (p - p_0)/\sqrt{(p_0(1 - p_0))/n}$$

where: "Z" represents the test outcome; "p" is the real population proportion; "p0" is the hypothetical population proportion and "n" is the number of samples collected from the population.

RESULTS

The PQ0 survey allowed identifying wood waste in the logging process, with lengths beyond the standard desired by the company. Improvements were observed in the assertiveness of the length of the logs, after the application of the first action plan (PQ1), therefore increasing the representativeness of the correct and acceptable quality levels, corresponding to less waste (Figure 2).

In PQ2, the adaptation of the measurement ruler resulted in an increase of 15.2% in assertiveness at the correct level, meeting the proposed goals at all levels. Also, it was found that the method to control wood waste provided greater agility in the process. Based on PQ2, the other results met the indicated targets, being above 70% at the correct level, and the increase in these values resulted from the reduction of the critical and unacceptable values, where the greatest loss of wood was observed for the company and the client.

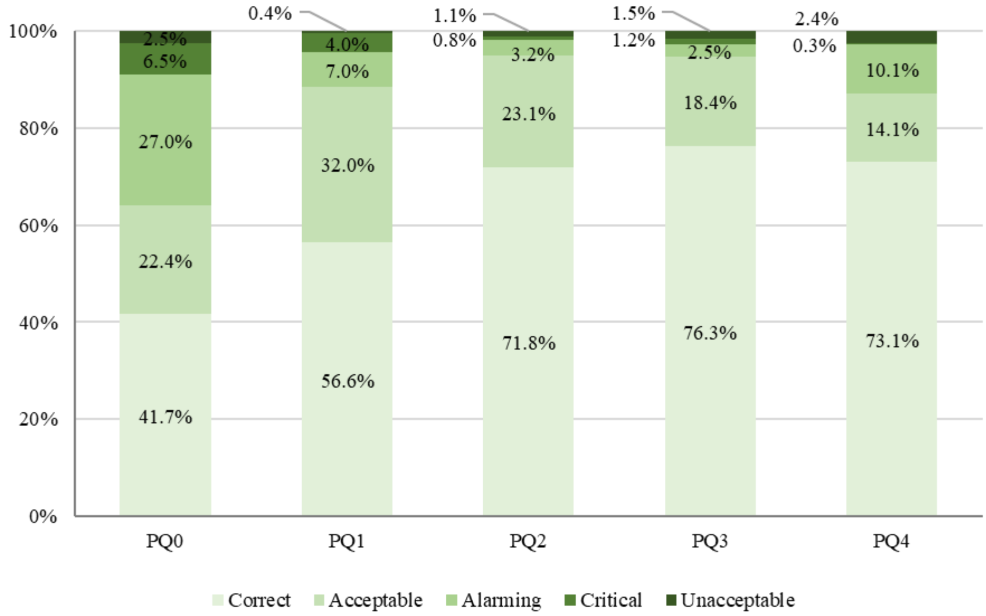

Figure 2. Percentage of wood waste levels by the control method per evaluated fortnight.
Figura 2. Percentagem dos níveis de desperdícios de madeira por meio do método de controle, por quinzena avaliada.

Using the data from the collections to test the method of controlling the wood waste, a simulation was carried out for three sizes of *Eucalyptus* sp. in each level of log assertiveness, whose wood waste outcomes are shown in Table 1.

Table 1. Simulation of the wood volume lost due to measurement error (excess) in different log assortments, with an average diameter of 40.0 cm, for each level of quality assessment.
Tabela 1. Simulação do volume de madeira perdida por erro de medição (excesso) em diferentes sortimentos de toras, com diâmetro médio de 40,0 cm, para cada nível da avaliação de qualidade.

Log length (cm)	**Correct (X)**		**Acceptable (X + 0.05)**		**Alarming (X + 0.10)**		**Critical (X + 0.15)**		**Unacceptable (X + 0.20)**	
	m^3	**%**	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**	**m^3**	**%**
400	0.7854	100.0	0.7952	101.3	0.8050	102.5	0.8149	103.8	0.8247	105.0
500	0.9817	100.0	0.9916	101.0	1.0014	102.0	1.0112	103.0	1.0210	104.0
600	1.1781	100.0	1.1879	100.8	1.1977	101.7	1.2075	102.5	1.2174	103.3

The shorter the length of the logs, the more representative the waste of wood as the measurement error increases. For comparison, regarding 400-cm length logs, for every 40 logs classified at the alarming level, the volume of one log is lost. For a log of 600 cm in length, the volume of one log is lost at every 60-log loss. At the unacceptable level, the volume of one log is lost for every 20 logs of 400 cm or 30 logs of 600 cm. This loss volume refers only to the measurement error above the required length. Measurement errors below what is required may result in greater losses due to the total disposal of the log.

Test of proportion between the survey outcome and the goal of the company

The results of the test of the proportion of the levels of each fortnight in relation to the company's goal, for the class of 550 cm logs, are shown in Table 2. The “h” represents the result obtained in the survey; “h0” is the company's goal; and the expression “Power”, represents the chance of rejecting hypothesis h0 and accepting hypothesis h.

Table 2. Analysis of the survey of each level in relation to the company's goals for 550-cm class logs, using a 0.05 significance level.
Tabela 2. Análise do levantamento de cada nível em relação as metas da empresa para toras de classe 550 cm, utilizando nível de significância 0,05.

Status		Fortnights				
		0	**1st**	**2nd**	**3rd**	**4th**
Correct	Power (%)	100.00	85.14	12.53	91.59	17.85
	h	0.3050	0.5111	0.6154	0.6929	0.6282
	h0	0.6000	0.6000	0.6000	0.6000	0.6000
Acceptable	Power(%)	22.30	15.96	33.38	49.37	12.45
	h	0.3359	0.3200	0.3360	0.2531	0.2821
	h0	0.3000	0.3000	0.3000	0.3000	0.3000
Alarming	Power (%)	100.00	57.63	55.19	66.90	39.78
	h	0.2061	0.0800	0.0283	0.0249	0.0769
	h0	0.0500	0.0500	0.0500	0.0500	0.0500
Critical	Power (%)	99.92	98.59	25.28	5.10	62.59
	h	0.1298	0.0800	0.0162	0.0249	0.0064
	h0	0.0250	0.0250	0.0250	0.0250	0.0250
Unacceptable	Power (%)	6.84	61.18	91.26	90.24	62.59
	h	0.0229	0.0089	0.0040	0.0041	0.0064
	h0	0.0250	0.0250	0.0250	0.0250	0.0250

This was also done for the 600-cm log class, where the results of the test of the proportion of the levels of each fortnight in relation to the company's goal are represented in Table 3.

Table 3. Analysis of the survey of each level in relation to the company's goals for 600 cm class logs, using a 0.05 significance level.
Tabela 3. Análise do levantamento de cada nível em relação as metas da empresa para toras de classe 600 cm, utilizando nível de significância 0,05.

Status		Fortnight				
		0	**1st**	**2nd**	**3rd**	**4th**
Correct	Power (%)	22.05	8.77	97.76	99.87	82.72
	h	0.5278	0.6200	0.8214	0.8333	0.8333
	h0	0.6000	0.6000	0.6000	0.6000	0.6000
Acceptable	Power (%)	89.12	9.03	94.76	99.33	0.00
	h	0.1111	0.3200	0.1250	0.1154	0.0000
	h0	0.3000	0.3000	0.3000	0.3000	0.0000
Alarming	Power (%)	99.88	9.10	13.25	30.86	37.69
	h	0.3333	0.0600	0.0357	0.0256	0.1250
	h0	0.0500	0.0500	0.0500	0.0500	0.0500
Critical	Power (%)	0.00	0.00	0.00	0.00	0.00
	h	0.0000	0.0000	0.0000	0.0000	0.0000
	h0	0.0000	0.0000	0.0000	0.0000	0.0000
Unacceptable	Power	6.18	0.00	10.08	5.36	11.79
	h	0.0278	0.0000	0.0179	0.0256	0.0417
	h0	0.0250	0.0000	0.0250	0.0250	0.0250

The test shows the rise in the assertiveness level with the application of action plans and achievement of the company's goals in the first fortnight, for 550-cm and 600-cm logs. Thus, it can be seen that the management and planning work carried out in the first fortnight was understood by the operators.

However, at the correct level of the 550-m log class, the test showed that the company's goal only started to be achieved in the second fortnight. At the correct level of the 600-cm log class, the objective was achieved in the first fortnight and presented a significant evolution in the following fortnights. The test also showed that the adaptation performed on the operator's ruler in PQ2 was efficient, improving the assertiveness of the measurements.

For the proportion test comparing the results of each level of the fortnight “x”, with the previous fortnight “x-1”, where hypothesis h is the result of the level of the “current” fortnight, compared with the result of the survey of the fortnight background, for the 550 m log class (Table 4).

Table 4. Analysis of the survey of each level in comparison to the results obtained in the week preceding it, for class 550 m logs, using a 0.05 significance level.
Tabela 4. Análise do levantamento de cada nível em comparação aos resultados obtidos da semana que lhe antecede, para toras de classe 550 m, utilizando nível de significância 0,05.

Status		**Compared fortnights**			
		1st - 0	**2nd – 1st**	**3rd – 2nd**	**4th – 3rd**
Correct	Power (%)	100.00	95.22	81.28	52.53
	H	0.5111	0.6154	0.6929	0.6282
	h0	0.3053	0.5111	0.6154	0.6929
Acceptable	Power (%)	12.78	13.37	88.19	20.43
	H	0.3200	0.3360	0.2531	0.2821
	h0	0.3359	0.3200	0.3360	0.2531
Alarming	Power (%)	99.99	98.01	9.40	92.16
	H	0.0800	0.0283	0.0249	0.0769
	h0	0.2061	0.0800	0.0283	0.0249
Critical	Power (%)	79.09	99.96	24.59	62.28
	H	0.0800	0.0162	0.0249	0.0064
	h0	0.1298	0.0800	0.0162	0.0249
Unacceptable	Power (%)	53.11	25.32	5.26	10.66
	h	0.0089	0.0040	0.0041	0.0064
	h0	0.0229	0.0089	0.0040	0.0041

Based on this test, it was possible to show, for both classes, the positive evolutions in the assertiveness levels with the progress of the experiment, from fortnight 1 to fortnight 3. However, comparing fortnight 3 with fortnight 4, we can see a slight decrease in the correct level and an increase in the alarming level of the fourth fortnight of the 550-cm log class, evidenced by the reduction of the power of the correct level test and an increase in the power of the worrisome level of the fortnight 4.

Table 5. Analysis of the survey of each level in comparison to the results obtained from the week preceding it, for logs of class 600 cm, using a 0.05 significance level.
Tabela 5. Análise do levantamento de cada nível em comparação aos resultados obtidos da semana que lhe antecede, para toras de classe 600 cm, utilizando nível de significância 0,05.

Status		**Purchased fortnights**			
		1st - 0	**2ª - 1ª**	**3ª - 2ª**	**4ª - 3ª**
Correct	Power (%)	37.28	96.13	8.59	5.00
	h	0.6200	0.8214	0.8333	0.8333
	h0	0.5278	0.6200	0.8214	0.8333
Acceptable	Power (%)	97.99	97.41	8.32	0.00
	h	0.3200	0.1250	0.1154	0.0000
	h0	0.1111	0.3200	0.1250	0.0000
Alarming	Power (%)	99.98	21.59	13.02	62.60
	h	0.0600	0.0357	0.0256	0.1250
	h0	0.3333	0.0600	0.0357	0.0256
Critical	Power (%)	0.00	0.00	0.00	0.00
	h	0.0000	0.0000	0.0000	0.0000
	h0	0.0000	0.0000	0.0000	0.0000
Unacceptable	Power (%)	0.00	0.00	11.96	11.42
	h	0.0000	0.0000	0.0256	0.0417
	h0	0.0000	0.0000	0.0179	0.0256

Regarding the class of 600-cm logs (Table 5), the correct level was the only one in which assertiveness was stabilized, evidencing positive results of the standardization of the operation and project outcome. It is also observed in both log classes, immediate changes in assertiveness from fortnight 0 to fortnight 1, showing the importance of elaboration and operational procedures and quality controls in operations.

DISCUSSION

The target of 60% of logs at the correct level was not achieved in PQ1; nevertheless, the importance of implementing standard operating procedures and quality controls was observed, which resulted in an increase in the correct (14.9%) and acceptable (9.6%) levels and a reduction of the other levels, where there is a greater wood waste. In comparing PQ1 and PQ2, when the measurement ruler was adapted, an increase of 15.2% of the correct level was seen, reaching the goal established by the company. This result shows the importance of using a measuring instrument with greater precision and practicality, allowing significant gains. Jacovine *et al*. (1999), realize that the permanent analysis and monitoring of operations enable new ideas and alternatives for improvements, which can optimize the process, reducing waste and thus allowing the complete use of goods and products.

The company's demand considers the goal of 90% to be coherent, with 60% at the correct level and 30% at the acceptable level. In the reading carried out in the PQ0 period, this sum totaled 64.1%, a value below the recommended target. After the first action plan (PQ1), the sum of these levels had already reached the percentage of 88.6%. In PQ2, the quality level of the operation was already close to 95%. In PQ3, this level was maintained with an increase of 4.7% of the correct level, a value that was reduced from the acceptable level. In the last PQ4 evaluation, there was a reduction in the acceptable level and an increase in the alarming level, in relation to PQ3, due to the error made by the operator when preparing the measuring tape used at the 600-cm log cutting. In addition, the unacceptable and critical levels remain at 2.7%, demonstrating that serious measurement errors can be minimized by operating the task carefully.

In addition, by observing the stabilization of the correct and acceptable levels around 94% in the 2 and 3 fortnights, it is possible to establish a minimum percentage of assertiveness of the length of logs of 90.0%, between the correct and acceptable levels, and establish a target of 80.0% of assertiveness for the correct level, in which there is less waste of wood. Alves *et al*. (2013) infer that the assessment of the ideal size of the logs contributes to the decision-making process by managers for the best use of the product and economic gains resulting from the increase in operational efficiency, productivity, in addition to providing confidence to the project.

Another important action observed during the work is the review of training and the search for new measurement methods that can make the work faster and more accurate, resulting in gains for the company.

Costa and Jardim (2017) stress out that, based on the result of the indicators, managers and/or the team responsible for the operation can develop the company's intelligence systems. Then, with a structured basis of data processing, it is possible to take corrective measures and even changes that will be able to improve, optimize and facilitate the operation. Marcosué *et al*. (2013) add that it is important to evaluate the product before it is delivered to the final customer, thus avoiding dissatisfaction, in addition to avoiding a possible reduction in the number of sales. They also point out that a pre-sale evaluation of the product quality may add value and show the company's commitment to delivering the product corresponding to what was requested.

CONCLUSIONS

- The method proposed for log measuring focused on the quality control of logging, providing at the end of the study a reduction of 98.1% in wood volume losses, when compared to the initial scenario used by the company until then, optimizing the products generated from each tree.
- The assessment of the scenario through action plans for a fortnightly period, enabled the monitoring of the performance of the log measurements over time and the short-term adjustments, as well.
- The quality scale developed and tested was validated by the company's technical team, as well as by the log buyers.
- It is recommended to increase the number of measurement evaluations for each and of the extracted assortments, to better evaluate the gains with quality control, reduce the time of perception, and correction of errors that can result in large losses. Also, the acquisition and use of a forest metric tape are recommended.

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REFERENCES

ALVES, R. T., FIEDLER, N. C., SILVA, E. N., LOPES, E. S., CARMO, F. C. A. Análise técnica e de custos do transporte de madeira com diferentes composições veiculares. **Revista Árvore**, Viçosa, v. 37, n. 5, p. 897-904, Oct. 2013.

BAUMGARDNER, M. Introdução à pesquisa de Marketing. In.: MALHOTRA, N.K. **Pesquisa de marketing**: uma orientação aplicada. 6ª edição, Porto Alegre: Bookman, 2012. 736 p.

CAMPOS, V. F. **TQC**: Controle de qualidade total – no estilo Japonês. Belo Horizonte: QFCO, 8ª edição, 2004. 256 p.

CORRÊA, H. L.; CORRÊA, C. A. **Administração de Produção e Operações: o essencial**. 3ª edição, São Paulo: Atlas, 2017, 632 p.

COSTA, R. S.; JARDIM, E. G. M. **Gestão de operações de produção e serviços**. 1. ed. São Paulo: Atlas, 2017, 358 p.

FERNANDES, B. H. R.; BERTON, L. H. **Administração estratégica**: da competência empreendedora à avaliação de desempenho. São Paulo: Saraiva. 2ª edição, 2012. 177 p.

FOELKEL, C. **Gestão ecoeficiente dos resíduos florestais lenhosos da eucaliptocultura**. 2007. 49 p. Disponível em: <http://www.eucalyptus.com.br/capitulos/PT07_residuoslenhosos.pdf>. Acesso em: 20 jun. 2019.

JACOVINE, L.A.G.; REZENDE, J. L. P.; SOUZA, A.P.; LEITE, H.G.; TRINDADE, C. Descrição e uso de uma metodologia para avaliação dos custos da qualidade na colheita florestal semimecanizada. **Ciência florestal**, Santa Maria, v. 9, n. 1, p. 143-160, Jan-Jun, 1999.

LACHTERMARCHER, G. **Pesquisa operacional na tomada de decisões**. São Paulo: Person Prentice Hall, 2009. 220 p.

MARCOSUÉ, I.; SURRIDGE, M.; GILLESPIE, A. **Gestão de operações**. Tradução de Giovanna Matte e revisão técnica de Leandro Morilhas. 1ª edição, São Paulo: Saraiva, 2013, 291 p.

PÉLLICO NETTO, S.; BRENA, D. **Inventário florestal**. Curitiba: Universidade Federal do Paraná, 1997, 316 p.

SERPE, E. L.; FIGUEIREDO FILHO, A; ARCE, J. E. Perdas volumétricas relativas à colheita florestal e seus reflexos econômicos. **BIOFIX Scientific Journal**, Curitiba, v. 3, n. 1, p. 172-176, 2018. Disponível em: < dx.doi.org/10.5380/biofix.v3i1.58054>. Acesso em: 19 jul. 2019.

SOUSA, R.S.; MAFFRA, C. R. B.; DEWES, J. J.; PINHEIRO, R. J. B.; SUTILI, F. J. Engenharia Natural: O uso e avaliação das plantas de uma perspectiva de engenharia. **Scientia Vitae**, v. 9, n. 27, p. 1-13, Jan-Mar, 2020.

TRINDADE, C.; JACOVINE, L.A.G.; REZENDE, J. L. P.; SARTÓRIO, M. L**. Gestão e controle de qualidade na atividade florestal**. Viçosa: UFV, 2ª edição, 2017. 253 p.

VATRAZ, S.; BORGES, F. Q. Procedimentos de controle do volume de madeira estimado e colhido em um plantio de *Pinus* spp. no Paraná. **Ciência Florestal**, Santa Maria, v. 24, n. 2, p. 445-453, 2014.