REDUCTION NATURAL REGENERATION DENSITY OF *Pinus elliottii* BY MANUAL AND MECHANIZED MOWING

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Resumo

Condução da regeneração espontânea de Pinus elliottii por roçada manual e mecanizada. Os métodos de condução da regeneração natural de *Pinus elliottii* são alternativas aos plantios com mudas, em que roçadas manuais ou mecanizadas são realizadas para reduzir a competição (densidade), ao passo que desbastes seletivos são aplicados para selecionar os indivíduos mais promissores. Dessa forma, o presente estudo teve como objetivo comparar métodos de condução da regeneração natural de *Pinus elliottii* com base nas variáveis biométricas florestais: densidade de árvores (N), área basal (G), injúrias nas árvores remanescentes (I) e custo de produção. Para isso, foram alocadas 19 parcelas circulares de 380 m² em uma área experimental de roçada manual com 22,5 ha e 6 parcelas em uma área de roçada mecanizada com 7,2 ha. O teste de *Mann-Whitney* para amostras independentes foi utilizado para verificar a existência de diferença estatística entre as varáveis discretas *N* e *I*, ao passo que o teste *t* de *Student* de duas amostras, presumindo variâncias diferentes, foi aplicado para a variável contínua *G*, ambos ao nível de 5% de significância. Com N− de 2.012 árvores/ha e G− de 4,07 m²/ha, a roçada mecanizada apresentou maior eficácia no controle da regeneração. Não foi encontrada diferença estatística entre os métodos referente à *I*, enquanto o custo de produção da roçada manual foi 51,7% maior. Assim, conclui-se que o método com roçada mecanizada é o mais indicado para a condução da regeneração natural de *Pinus elliottii*.
Palavras-chave: Regime de manejo; Tratos silviculturais; Rolo faca.

Abstract

The methods of conducting the natural regeneration of *Pinus elliottii* are alternatives to planting with seedlings, where manual or mechanized mowing is carried out to reduce competition (density), while selective thinning is applied to select the most promising individuals. Thus, this study aimed to compare methods of conducting the natural regeneration of *Pinus elliottii* based on forest biometric variables: tree density (N), basal area (G), injuries to the remaining trees (I) and production cost. For this, 19 circular plots of 380 m² were allocated in an experimental area of manual mowing with 22.5 ha and 6 plots in a mechanized mowing area with 7.2 ha. The *Mann-Whitney* test for independent samples was used to verify the existence of statistical difference between the discrete variables *N* and *I* , while the test *t* of *Student* de two samples, assuming different variances, were applied to the continuous variable *G*, both at the level of 5% significance. With $\bar{N}$ of 2,012 trees/ha and $\bar{G}$ of 4.07 m²/ha, mechanized mowing was more effective in controlling regeneration. No statistical difference was found between the methods referring to *I*, while the production cost of manual mowing was 51.7% higher. Thus, it is concluded that the method with mechanized mowing is the most suitable for conducting the natural regeneration of *Pinus elliottii*.
Keywords: Management Regime; Silvicultural Tracts; Drum Chopper.

INTRODUCTION

Forestry of the genus *Pinus* is one of the main sources of raw material for the forest-based industry in southern Brazil, which has an important participation in the national economy (VASQUES *et al*., 2007). In order to obtain greater control over the propagated material, low mortality rate and, mainly, to guarantee greater growth potential, the establishment of forest stands is often carried out with the introduction of trees in site in the form of seedlings produced in a nursery (CRUZ *et al.*, 2006).

However, according to Ferrari *et al*. (2017), mainly due to environmental zoning, the planting of exotic species is prohibited by law in some regions of Brazil, where, when possible, the continuation of the cultivation of these species is usually done through the conduction of natural regeneration the seed bank of the areas after harvesting the wood.

According to Silva *et al.* (2018), the seed tree method for the establishment of forest stands is not a widespread practice in the country and can compromise the development of trees. However, it provides a great reduction in the initial costs of forestry projects, eliminating the expense of buying seedlings, site preparation,

leafcutter ant and weed control. Nonetheless, this practice requires silvicultural interventions in order to reduce the density of plants, provide greater growth in diameter and direct the forest to the yield of resin and wood.

The methods of conduction of the natural regeneration of *Pinus elliottii* are divided in two stages: mowing and selective thinning from below. The mowing one has the objective to diminish the competition, controlling the initial density of trees, to the step that the selective thinning from below has as objective to select the individuals phenotypically more promising and to organize forest stand (FINGER space *et al*. , 2003). Being able to be practiced of manual or mechanized form, the mowing stage of differentiates the two methods of practiced conduction of regeneration. In the manual method, the mowing is done with the use of sickles, while in the method with mechanized mowing, a tractor with a drum chopper is used (CALDEIRA; CASTRO, 2012).

There is a hypothesis that the mowing methods differ in terms of the efficiency of this silvicultural tract in controlling regeneration, in the cost of production and, also, in injuries to the remaining trees, which can harm the production of resin. Thus, the objective of the present work was to compare methods of conducting the natural regeneration of *Pinus elliottii* in stands managed for the yield of resin.

MATERIAL AND METHODS

Study area

The areas where the data were collected are located in the municipality of Cidreira, on the coast of the state of Rio Grande do Sul, at an altitude of 3 to 5 m and under marine or river influence. According to the Köppen classification, the region's climate is Cfa type, humid subtropical with no dry season, with hot summer, average annual temperature of 18 and 19 °C and annual rainfall of 1,300 mm. The soil is of the eutrophic hydrosorphic planossol type (LANZER *et al*., 2013).

Population and sampling

In the study area, a stand of *Pinus elliottii* was clear cut in 2010, whose seed bank remaining in the soil began to germinate, initiating a seedbed. In the second half of 2016, at 6 years of regeneration, data collection was carried out with the allocation of 380 m² circular sampling units by the simple random sampling process.

This study compared two different methods of conducting the natural regeneration of *Pinus elliottii*: 1) manual mowing conducted in an area of 22.5 hectares, in which 19 sample units were randomly sampled; and 2) mechanized mowing conducted in an area of 7.2 hectares, with 6 sampling units measured. In both methods, the sample intensity was proportional to the area of each experiment, resulting in approximately one sampling unit for every 1.2 hectares.

Natural regeneration conducting methods of *Pinus elliottii*

The two methods of conducting natural regeneration have the mowing and selective thinning steps (Figure 1), aiming, respectively, at reducing the density of the stand and the selection of trees of greater height and diameter. In the method with manual mowing, this stage was performed with sickle by a team of 25 workers at 5 years of age of the stand. Approximately every 20 m, a seedling-free strip of *Pinus elliottii* was left in the field.

Figura 1. Áreas em atividade de roçada manual com foice (a) e em roçada mecanizada com rolo faca (b).
Figure 1. Areas in manual mowing with scythe (a) and mechanized mowing with drum chopper (b).

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At 6 years of age, selective thinning was performed and pruning the trees up to a height of 2.0 m (Figure 1a). In the method with mechanized mowing, the operation was performed with a rolling chopper, in which the first mechanized mowing was performed on regeneration at 5 years of age, aiming at the opening of between rows with 3.5 m width. At 6 years of age, a second operation was performed with drum chopper on the same interrow performed in the first mowing operation, with the objective of reducing the dead layer of vegetation. Then, selective thinning was performed on the strip left by the drum chopper operation, reducing the number of specimens and respecting the distance of 1.0 m per plant (Figure 1b).

After data collection, for a better interpretation of the characteristics of the stands, descriptive analysis of the data and grouping of the trees in diameter classes at 1.3 m from the soil (*d*) were performed to observe the diameter distribution of the areas.

Density and basal area analysis

In the sample units, all trees were measured and tree density per hectare, basal area and sampling errors were calculated. To verify a possible statistical difference in tree density per hectare, the nonparametric test of *Mann-Whitney* was applied for independent samples at the level of 5% significance. For the basal area, the normality test of *Shapiro-Wilk* was first performed, then the equality of variances was verified by the *F* test and, finally, the *t* test of *Student* of two samples was performed, assuming different variances, at the level of 5% significance.

Qualitative analysis of manual and mechanized mowing

The quality of the manual and mechanized mowing was evaluated based on the number of trees in the plot with injuries in the trunk. The injuries found in the sample units of the area with manual mowing corresponded to the removal of the bark caused by the accidental blow of the sickle. In the mechanized area, the damage caused was related to the removal of the bark of the trunk by the passage of the tractor in the corridor and possible contact of the tractor tires with the trees. Due to the width of the axle and rear wheels of the tractor, the regeneration close to the corridor is achieved by the roller but is not eliminated (Figure 2).

Figura 2. Injúrias em fuste de *Pinus elliotti* ocasionado por rodado de trator.
Figure 2. Injuries on the trunk of *Pinus elliotti* caused by tractor wheel.

To verify the existence of statistical difference between the injuries caused by the two types of mowing in the remaining trees, the test of *Mann-Whitney* was also applied for independent samples at the level of 5% significance. Although the nonparametric test of *Mann-Whitney* uses the median for the calculation, the mean values of the variables were presented in the tables to better understand the information.

Production cost analysis

The analysis of production costs for manual and mechanized mowing activities was adapted from the methodology presented by Schettino *et al*. (2015). The production cost (PC) was calculated by the ratio between the operational cost (OC) budgeted for the mowing operations and the productivity (Prod) of the team or equipment

(1), and the operational cost was established by the determination of fixed, variable and administrative costs of the operations in the time interval, in which the activities were carried out in the areas studied.

$$CPr = \frac{CT}{Prod} \tag{1}$$

Where: PC = production cost (R$/ha); OC = operational cost (R$/ha); and Prod = Productivity (ha).

RESULTS

Characteristics of the studied areas

The mean diameter value ($\bar{d}$) found for the manual mowing area was 10.50 cm, with a standard deviation of 1.92 cm, while the mean total height ($\bar{h}$) was 6.98 m, with a standard deviation of 0.98 m. For the area of mechanized mowing, it was observed $\bar{d}$ of 4.88 cm, with standard deviation of 0.51 cm, and $\bar{h}$ of 3.99 m, with standard deviation of 0.52 m.

Although they appear to belong to different stages of development, it was possible to notice a strong tendency to unimodality in the diameter distribution in the two study areas. However, in the area of mechanized mowing, there was a marked increase in the concentration of individuals from class 1 to 3 (Figure 3b), while in the area of manual mowing, there was a greater tendency to normality (Figure 3a).

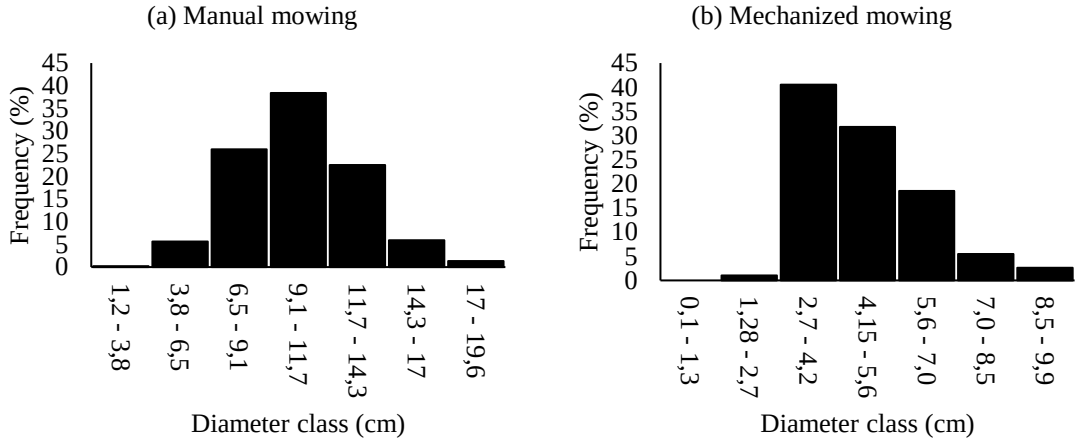

Figura 3. Distribuição diamétrica das áreas de roçada manual (a) e mecanizada (b).
Figure 3. Diameter distribution of the manual (a) and mechanized (b) mowing areas.

Density and average basal area

In the manual mowing area, the relative sampling error was 9.82%, while in the mechanized mowing area, the error corresponded to 15.7%. The test result of *Mann-Whitney* for the analysis of natural regeneration density of *Pinus elliotti* in the areas of manual and mechanized mowing is presented in Table 1.

Tabela 1. Análise estatística de densidade em áreas de *Pinus elliotti* submetidas as roçadas manual e mecanizada.
Table 1. Statistical analysis of density in areas of *Pinus elliotti* submitted to manual and mechanized mowing.

Variable	Mowing	*N* (N/ha)	*U* to trace.	*P- value*
Density	Manual	2.620	93,50	0,0219*
	Mechanized	2.013		

Where: *W*calc.= test statistic *Mann-Whitney* ; *P-value* = probability of significance of test *U*; ns = not significant; and * = significant at 5% probability.

It was possible to observe statistical difference between the mowing areas. The superiority of the average number of individuals/ha found in the area of manual mowing, in relation to the mechanized mowing, was

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approximately 30.15%. The results of the Tests of Shapiro-Wilk (SW), *F* and *t* of *Student* for the analysis of the basal area of the areas of manual and mechanized mowing is presented in Table 2.

Tabela 2. Análise estatística de área basal em áreas de *Pinus elliottii* submetidas as roçadas manual e mecanizada.
Table 2. Statistical analysis of basal area in areas of *Pinus elliottii* submitted to manual and mechanized mowing.

Variable	Mowing	Test *SW* *P- value*	Test *F* *P- value*	$\bar{G}$ (m ² /ha)	df	*t* to trace.	Test *t* *P- value*
Basal Area	Manual	0,4416	1,65E-04	23,66	20	10,63	1.1E-09*
	Mechanized	0,3271		4,07			

In which: df = degrees of freedom; Test *SW P- value* = probability of significance of test *SW;* Test *F P- value* = probability of significance of test *F; t* calc.= test statistic *t* of *Student* ; Test *t P-value* = probability of significance of the test *t*; ns = not significant; and * = significant at 5% probability.

A statistical difference was observed for the average basal area, as well as for the density of trees. The basal area found for the manual mowing area was approximately 481% larger than that found for the area of mechanized mowing.

Manual and mechanized mowing quality

The percentage of trees reviled in relation to the average density calculated was 2.17% for the manual mowing area and 3.48% for mechanized mowing. The test result of *Mann-Whitney* for the analysis of injuries caused by mowing types is shown in Table 3.

Tabela 3. Análise estatística de injúrias em fuste causadas por roçadas manual e mecanizada.
Table 3. Statistical analysis of trunk injuries caused by manual and mechanized mowing.

Variable	Mowing	$I\ (i/ha)$	*U*to trace.	*P- value*
Injuries	Manual	57	92,50	$0{,}0722^{ns}$
	Mechanized	70		

Where: *W*calc.= test statistic *Mann-Whitney* ; *P-value* = probability of significance of test *U*; ns = not significant; and * = significant at 5% probability.

Although the area of mechanized mowing presents mild superiority of trees with injuries, no statistically significant difference was observed between injuries caused in the areas of manual and mechanized mowing.

Production cost

The average cost of production (R$/ha) for operations performed in the manual mowing area was approximately 51.7% higher than mechanized (Table 4). Thus, it can be noted that, for the mechanized area, the 1st and 2nd passage of the drum chopper resulted in low cost values when compared to manual interventions, demonstrating that mechanized mowing becomes economically viable when the operation has acceptable amounts of operational interruptions (preventive and corrective maintenance, supply, displacements, supervisions, jam, among others) and non-operational interruptions (personnel displacement , physiological needs of the operator, food, weather conditions for the activity, among others).

Tabela 4. Custo de produção das atividades de roçada manual e mecanizada.
Table 4. Production cost of manual and mechanized mowing activities.

Activity	Manual Mowing	Mechanized Mowing
1st Mowing with sickles (R$/ha)	1.073,0	-
2nd Selective thinning (R$/ha)	1.145,5	1.129,9
1st Passage with drum chopper (R$/ha)	-	177,7
2st Passage with drum chopper (R$/ha)	-	154,4
Total (R$/ha)	2.218,5	1.462,0

The number of passages with the drum chopper is related to the stage of development of the trees present in the area. Thus, after the first passage of the drum chopper in the mechanized area, the larger trees were overturned by the implement, requiring a second passage of the drum chopper in order for the regeneration to reach the desired mortality level.

DISCUSSION

Through the characteristics of the two areas of conduction of natural regeneration of *Pinus elliottii*, it is possible to evidence the heterogeneity of the stand and the presence of significant inferiority of individuals in the area conducted with mechanized mowing, which is probably related to the stage of development of individuals and/or site.

Since the diameter distribution allows describing the structure of a forest stand in a simple and efficient way (LOETSCH *et al*., 1973), it is possible to observe that the two areas present unimodal diameter distribution, similar to the distributions found by Téo *et al*. (2011) for plantations of *Pinus taeda* aged 5 years, located in the region of Caçador, SC. According to Téo *et al*. (2012), the unimodal form of a distribution is a characteristic of even-aged forest stands and, thus, with respect to the diameter structure, the areas of conduction of regeneration studied are similar to forest plantations.

Unlike the manual mowing area (Figure 3a), in the mechanized mowing, an abrupt change in the frequency of individuals between diameter classes one and three is visible (Figure 3b). Whereas, according to Bartoszeck *et al*. (2004), several management-related activities tend to change the diametric structure of forest stands, this change may be related to a more rigorous selection at the time of selective thinning, due to the greater visibility of those responsible for the selective thinning of trees in this area and probably related to the characteristics of the stand (lower $\bar{d}$ and $\bar{h}$) and the mechanized mowing itself (lower density and basal area), i.e. fewer individuals to be selected.

According to Bechara *et al*. (2013), the regeneration of the species *Pinus elliottii* is invasive and aggressive, causing, according to Bourscheid and Reis (2010), a regeneration density of 19,617 seedlings/ha to 166,624 seedlings/ha. As these values are considered high, the density control of natural regeneration is carried out in order to increase the commercial volumetric yield of wood and resin (SCHNEIDER; FINGER, 1994). Furthermore, considering the density of approximately 1,600 trees/ha practiced by forest producers (AGEFLOR, 2016), the results show that the regeneration density in the mechanized area is closer to that affected in commercial stands.

According to Kershaw Junior *et al*. (2016), the basal area is a useful information of a forest stand, because, in addition to the direct relationship with the volume, it is a measure of the density of the stand. The mean basal area value observed in the manual mowing area is close to 27.7 m²/ha found by Schneider and Finger (1994) in chopped stands of *Pinus elliottii* aged 7 years, planted with initial spacing of 2 m x 2 m in the western plateau of Santa Catarina.

On the other hand, the value found in area of mechanized mowing is lower than that found in the areas of manual mowing, as well as the values found by Mainardi *et al.* (1996) for stands of *Pinus taeda* L aged 4 years, in the northeast region of the state of Rio Grande do Sul, which presented basal area of 7.48 m²/ha and 7.92 m²/ha, for site indices of 16 m and 18 m, respectively. This is due to forest biometric characteristics and the origin of trees when compared to the studies cited.

The drum chopper significantly decreased the density of the stand, due to the opening of between corridors of 3.5 m for the passage of the tractor and, additionally, it was also noted the opening of clearings in the field by the maneuvers performed by the drum chopper. However, for the manual mowing area, the premise of opening corridors at 20 m intervals was adopted, thus, the spacing and dispersion of the trees became different from each other. Thus, the area of manual mowing, after the intervention, presented heterogeneous spatial distribution, while the area of mechanized mowing showed a more homogeneous distribution, similar to a planted forest.

Regarding the quality of manual and mechanized mowing, although no statistical difference was found by means of the nonparametric test, it was observed that the number of trees with injuries was lower in the manual mowing area. As observed by Oliveira *et al*. (2012), when evaluating the quality of semi-mechanized pruning in stands of *Pinus taeda*, it is possible to relate the level of training and orientation of the crews with the occurrence of injuries. Thus, the greater the ability of team members who perform manual mowing, the lower the average percentage of injuries per hectare.

It was also found that the level of damage caused to the trees by the tractor wheel in the mechanized area was more aggressive to the trees trunk, when compared to the area of manual mowing. This caused the removal of bark, wood injury and decreased rooting of the trees by their contact with the tractor wheel.

According to Martins *et al*. (2010), mechanical injuries can impair the health of trees, leaving them exposed to external agents. Regarding the objectives of the cultivation of *Pinus elliotti* in the region of the study area, the damage caused to the trees can cause reduction in growth, resin yield and log quality, so mitigating the occurrence of injuries in the activities is of great importance for the success of the enterprise.

As a possible solution the highest incidence of damage to the trees, it is suggested that in the area of mechanized mowing, this operation is performed with a drum chopper with a width greater than the tractor shaft.

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Thus, all vegetation hit by the tractor wheel, will later be removed by the drum chopper. Another alternative is the use of wheels with smaller widths, which would avoid contact with the trees.

In selective thinning, although all teams are instructed to eliminate forked, tortuous trees with low *d* and *h*, the highest percentage of forked trees, tortuous trees and branch stubs (part of the branch in the trunk not cut by the sickle) was observed in the area of manual mowing. This fact is probably related to the visibility of workers, since, when comparing the methods, different from the manual mowing area, the opening of the corridors resulting from the passage of the drum chopper in the area of mechanized mowing tends to increase the field of vision of the workers, thus facilitating the selection of the trees to be eliminated.

When analyzing the profitability of the cultivation of *Pinus* sp. in the mesoregions of the state of Paraná, considering the mechanized and manual production systems of establishment, Berger *et al*. (2011) report that, for medium and large producers, mechanization in the implantation of *Pinus* sp. cultivation has become a routine practice over the years and they state that, in scale, the use of tractors increases productivity and reduces production costs.

In relation to the production cost in the two mowing systems, high values were observed in manual mowing, mainly due to the fixed costs of salaries, charges, transportation, bonuses and medical care having relevance in the total composition of the production cost, being increased the costs related to repairs and changes of tools and personal protective equipment.

In mechanized mowing, in addition to the fixed costs of salaries and bonuses were lower than the manual system, production costs were influenced by maintenance, fuel and lubricant expenses. It is also important to note that such costs are subject to possible changes. Although the scenarios presented are the most recurrent, a greater number of passages with the drum chopper may be necessary. Thus, even though each drum pass has a much lower cost than manual labor, it is important to emphasize the need for structured planning to establish optimal moments of interventions in regeneration.

Finally, even though mechanized mowing is more advantageous in terms of financial and productivity, it is important to highlight the existence of limiting factors for its use. The characteristics of the stand, such as trees with a height greater than 3 m and *d* greater than 10 cm, tend to reduce the field of vision of the operator, decrease the productivity of operations and increase the risk of accidents at work, making the activity unfeasible. Other factors such as: irregular field, rough terrain, high stumps, poorly drained soils and high number of drainage channels, make the operation with drum chopper impractical, as they increase the number of maneuvers, the risk of jam and the maintenance of the machines.

CONCLUSIONS

- Mechanized mowing is more effective in controlling regeneration density and lower production cost compared to manual mowing, not differing statistically in the number of injuries in the wood of trees.
- Although it is the most indicated for the evaluated conditions, it is important to emphasize that are limitations to the use of mechanized mowing. The stage of development of regeneration, topography, and drainage of the land must be considered.

REFERENCES

AGEFLOR - ASSOCIAÇÃO GAÚCHA DE EMPRESAS FLORESTAIS. **A Indústria de Base Florestal no Rio Grande do Sul.** 2016. Disponível em: http://www.ageflor.com.br/noticias/wp-content/uploads/2016/09/AGEFLOR-DADOS-E-FATOS-2016.pdf/. Acesso em: 14/10/2017.

BARTOSZECK, A. C. P. S.; MACHADO, S. A.; FIGUEIREDO FILHO, A.; OLIVEIRA, E. B. A distribuição diamétrica para bracatingais em diferentes idades, sítios e densidades na Região Metropolitana de Curitiba. **Floresta**, Curitiba, v. 34, n. 3, p. 305 - 323, 2004.

BECHARA, F. C.; REIS, A.; BOURSCHEID, K.; VIEIRA, N. K.; TRENTIN, B. E. Reproductive biology and early establishment of *Pinus elliottii* var. *elliottii* in Brazilian sandy coastal plain vegetation: implications for biological invasion. **Scientia Agrícola**, Piracicaba, v. 70, n. 2, p. 88 - 92, 2013.

BERGER, R.; JÚNIOR, R. T.; SANTOS, A. J.; BITTENCOURT, A. M.; SOUZA, V. S.; EISFELD, C. L.; POLZ, W. B. Rentabilidade econômica da produção de *Pinus spp*. por mesorregião homogênea no estado do Paraná. **Floresta**, v. 41, n. 1, 2011.

BOURSCHEID, K; REIS, A. Dinâmica da invasão de *Pinus elliottii* Engelm. em restinga sob processo de restauração ambiental no Parque Florestal do Rio Vermelho, Florianópolis, SC. **Biotemas,** Florianópolis, v. 23, n. 2, p. 23 – 30, 2010.

CALDEIRA, S. F.; CASTRO, C. K. C. Herbicidas e danos físicos em tocos de teca para controle de brotos após o desbaste. **Ciência Rural**, v. 42, n. 10, 2012.

CRUZ, C. A. F.; PAIVA, H. N.; GUERRERO, C. R. A. Efeito da adubação nitrogenada na produção de mudas de sete-cascas (*Samanea inopinata* (Harms) Ducke). **Revista Árvore**, v. 30, n. 4, 2006.

FERRARI, L. S.; NAKAJIMA, N. Y.; SILVA, S. A.; ANSOLIN, R. D.; MOREIRA, D.; CIARNOSCHI, L. D.; KASPRZAK, L. F. F. Equações de volume para condução da regeneração natural de *Pinus elliottii* Engelm. **Revista Espacios**, Caracas, v. 38, n.42, p.19 - 31, 2017.

FINGER, G. C. A.; SCHNEIDER, P. R.; GARLET, A.; ELEOTÉRIO, J. R.; BERGER, R. Estabelecimento de povoamentos de *Pinus elliottii* Engelm pela semeadura direta a campo. **Ciência Florestal**, v. 13, n. 1, 2003.

KERSHAW JUNIOR, J. A.; DUCEY, M. J.; BEERS, T. W.; HUSCH, B. **Forest mensuration**. John Wiley & Sons, 2016. 633 p.

LANZER, R. M.; CASTRO, V. R.: MARCHETT, C. A. Impactos ambientais do turismo em lagoas costeiras do Rio Grande do Sul. **Caderno Virtual de Turismo**, v. 13, n. 1, 2013.

LOETSCH, F.; ZÖHRER, F.; HALLER, K. E. **Forest Inventory.** München: BLV Verlagsgesellschaft, 1973. v. 2. 469 p.

MAINARDI, G. L.; SCHNEIDER, P. R.; FINGER, C. A. G. Produção de *Pinus taeda* L. na região de Cambará do Sul, RS. **Ciência florestal**, v. 6, n. 1, p. 39-52, 1996.

MARTINS, L. F. V.; ANDRADE, H. H. B.; ANGELIS, B. L. D. Relação entre podas e aspectos fitossanitários em árvores urbanas na cidade de Luiziana, Paraná. **Revista da sociedade brasileira de arborização urbana**, v. 5, n. 4, p. 141-155, 2010.

OLIVEIRA, F. M.; LOPES, E. S.; MALINOVSKI, J. R.; SILVA, R. H.; RODRIGUES, C. K. Avaliação técnica e de custos de poda manual e semimecanizada em plantios de *Pinus taeda*. **Floresta**, v. 42, n. 4, p. 691-700, 2012.

SCHETTINO, S.; MINETTE, L. J.; SOUZA, A. P. Correlação entre volumetria de florestas de eucalipto e produtividade e custos de máquinas de colheita de madeira. **Revista Árvore**, v. 39, n. 5, 2015.

SCHNEIDER, P. R.; FINGER, C. A. G. Determinação de regimes de desbaste para povoamentos de *Pinus elliottii* E. do Planalto Ocidental no estado de Santa Catarina. **Ciência Florestal**, v. 4, n. 1, p. 43-59, 1994.

SILVA, S. A.; FERRARI, L. S.; MOREIRA, D.; LANSSANOVA, L. R.; ANSOLIN, R. D.; CIARNOSCHI, L. D.; NAKAJIMA, N. Y. Funções de afilamento para *Pinus elliottii* Engelm. proveniente de condução de regeneração natural. BIOFIX **Scientific Journal**, v. 3, n. 1, p. 130-136, 2018.

TÉO, S. J.; ROCHA, S. P.; BORTONCELLO, A. C.; PAZ, R. A.; COSTA, R. H. Dinâmica da distribuição diamétrica de povoamentos de *Pinus taeda*, na região de Caçador, SC. **Pesquisa Florestal Brasileira**, v. 31, n. 67, p. 183, 2011.

TÉO, S. J.; BIANCHI, J. C.; PELOSO, A.; NAVA, P. R.; MARCON, A.; EHLERS, T.; COSTA, R. H. Desempenho de funções de densidade probabilísticas para descrever a distribuição diamétrica de *Pinus taeda*, na região de Caçador, SC. **Floresta**, v. 42, n. 4, p. 741-754, 2012.

VASQUES, A. G.; NOGUEIRA, A. S.; KIRCHNER, F. F.; BERGER, R. Uma síntese da contribuição do gênero *Pinus* para o desenvolvimento sustentável no sul do Brasil. **Floresta**, v. 37, n. 3, 2007.