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FORESTRY RESTORATION IN ABANDONED PASTURES OF *Urochloa* BY DIFFERENT SIZES OF BRUSHWOOD

Keywords:
Inhibition
Nucleation
Facilitation
Restoration of degraded ecosystems
Natural regeneration

ABSTRACT: The brushwood is a technique of environmental complexation, which consists in the use of plant residues. This technique, when well established technically, can exert influence on seedbed quality, fostering native plant establishment and ecosystem restoration. In this way, we aimed to evaluate the efficiency of brushwood for the induction of natural regeneration of native species in an area covered by exotic inhibitory grasses of the genus *Urochloa*, as well as check the minimum size required to prevent the re-invasion of the forage. As a hypothesis, we adopted the minimum width of 4 m as sufficient for the establishment of natural regeneration prior to the reoccupation of grasses. The experiment was conducted between May 2014 and May 2016 in Morretes-PR in a lowland evergreen rain forest area. Seven different sizes of brushwood were compared: 6 x 1, 6 x 2, 6 x 3, 6 x 4, 6 x 5, 6 x 6 m and control treatment. Woody species were identified and counted and herbaceous cover percentage estimated after 4, 8, 12, 18 and 24 months. There was no resumption of natural succession of native species. At any size, brushwood alone was ineffective to prevent the growth by grasses from the edges of the plots, and, since it constitutes a residue pile, it further complicates the establishment of woody species. For the creation of safe sites and consequent restoration by natural regeneration, there is a need for local elimination of *Urochloa* forages, without which native species are unlikely to survive.

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RESTAURAÇÃO FLORESTAL EM PASTAGEM ABANDONADA DE *Urochloa* POR MEIO DE DIFERENTES TAMANHOS DE GALHARIA

Palavras chave:
Inibição
Nucleação
Facilitação
Recuperação de ecossistemas degradados
Regeneração natural.

RESUMO: A galharia é um método de complexação ambiental, que consiste no aproveitamento de resíduos vegetais. Esse método, quando bem estabelecido tecnicamente, pode exercer influência sobre a qualidade da cama de sementes, favorecendo o estabelecimento de plantas nativas e a restauração do ecossistema. Dessa forma, objetivou-se avaliar a eficiência de galharia para a indução da regeneração natural de espécies nativas em área coberta por gramíneas exóticas inibidoras do gênero *Urochloa*, bem como verificar o tamanho mínimo necessário para conter a reinvasão das forrageiras. Como hipótese, adotou-se a largura mínima de 4 m como suficiente para o estabelecimento da regeneração natural, antes da reocupação das forrageiras. O experimento foi conduzido entre maio 2014 e maio 2016 em Morretes-PR, na Floresta Ombrófila Densa de Terras Baixas. Foram implantados sete tamanhos de galharia: 6 x 1, 6 x 2, 6 x 3, 6 x 4, 6 x 5, 6 x 6 m e testemunha. As espécies lenhosas foram identificadas e contadas e a porcentagem de cobertura herbácea estimada após 4, 8, 12, 18 e 24 meses. Não se verificou retomada da sucessão natural por espécies nativas. Independentemente do tamanho, a galharia foi ineficiente para conter a reinvasão pelas gramíneas a partir das bordas das parcelas e, como pilha de resíduos, dificultou o estabelecimento de espécies lenhosas. Para a criação de *safe sites* e consequente restauração via regeneração natural, faz-se necessária a eliminação local das forrageiras *Urochloa*, sem a qual espécies nativas terão pouca probabilidade de sobreviver.

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INTRODUCTION

Brazil is a country with one of the greatest biodiversity of the planet (FORZZA et al., 2012), and one of today's greatest challenges is to preserve it, due to the high level of anthropogenic disturbances of natural ecosystems (LOYOLA, 2014). Even after the reduction of environmental liability by the new Brazilian Forest Act, the demand for restitution of permanent preservation areas and legal reserves remains high, reaching about 21 million hectares in Brazil (SOARES-FILHO, 2013).

Ecological restoration aims at organizing the practical cases of recovery of degraded ecosystems in a technical and operational way (DELLASALA et al., 2003; CARPANEZZI; NICODEMO, 2009). It is usually defined as a set of activities that contribute to the restoration of ecologically sustainable communities, facilitating or even promoting the environment's natural capacity to perpetuate itself over time (JACKSON et al., 1995; HIGGS, 1997).

When the methods of recovery of degraded ecosystems based on the facilitation and nucleation theories (REIS et al., 2003) are applied according to well defined technical requirements that are appropriate to the local reality, they represent an alternative to restoration. The use of techniques engaged in overcoming the natural regeneration barriers allows the resumption of succeeding processes according to each area's field capacity (REIS et al., 2010). It is expected that the changes in the environment act to facilitate the arrival and establishment of more advanced succession species, leading to the development of more stable plant communities (YARRANTON; MORRISON, 1974).

In general, the successional process occurs more easily when there is propagule availability and appropriate environmental conditions (ARAUJO et al., 2012). The natural regeneration in abandoned pastures is slow due to a series of factors that reduce colonization by native species (MAZA-VILLALOBOS et al., 2011). These factors stem from changes in the environment by the presence of exotic grasses, such as forage plants of the genus *Urochloa,* which act as natural regeneration inhibitor (BOCCHESE et al., 2008). Practices to improve the "seedbed" are important for the soil seed bank and seed rain to find "safe sites" for germination and establishment. Among them, the brushwood, nucleation technique that consists of covering the soil with inert plant residues, such as tree trunks and branches, aim at creating a favorable environment for the reoccupation by native species (REIS et al., 2003; CARPANEZZI; NICODEMO, 2009).

The brushwood in pastures aims to weaken the grasses due to soil shading (MARCUZZO et al., 2013). It is therefore important that the environmental complexation nuclei are big enough to withstand the pressure exerted by grasses with creeping habit and intense lateral spread. Minimum sizes have been required to delay the reoccupation by the forage plants, so that it enables the success of natural regeneration (CARPANEZZI; NICODEMO 2009). While there is not a good characterization of the necessary size of restoration nuclei, such methodologies cease to be effective over time (LEAL FILHO et al., 2013).

Thus, in this study, we assessed the induction of natural regeneration by brushwood in areas covered by exotic inhibitory grasses of the genus *Urochloa*, testing the hypothesis that the size of brushwood would influence the effectiveness of this technique.

MATERIAL AND METHODS

The experiment was conducted between May 2014 and May 2016 at the Experimental Station of Embrapa Florestas in Morretes, coastal Paraná region (25°26'56"S, 48°52'18"O), in the phytoecological region known as lowland evergreen rain forest. The relief is flat; the soil is Dystrophic Haplic Cambisol - CXbd (Oxic Dystrudepts) with moderate A horizon, clayey texture (EMBRAPA, 2006; SOIL SURVEY STAFF, 2014). The climate is classified by Köppen as Cfa, humid sub-tropical, reaching mean temperatures close to 17 °C in the coldest months and 24 °C in the warmest months, with infrequent frosts and trend of concentration of rainfall in the summer, but no defined dry season (IAPAR, 2015). The mean annual rainfall is between 2.000 and 2.200 mm and the mean annual temperature is close to 21 °C.

Initially, the area was used for agricultural crops and later was converted to pasture of the *Urochloa humidicola* (Rendle) Morrone & Zuloaga for buffalo breeding, remaining in this condition about 15 years. Afterwards, the area was abandoned for 10 years, when soil mechanization was performed using crawler bulldozers for vegetation removal, with consequent partial decapitation of the A horizon, being again abandoned for two years. During the pasture abandonment periods, the forages of African origin *Urochloa subquadripara* (Trin.) R.D.Webster and *Urochloa decumbens* (Stapf) R.D.Webster) invaded the area, becoming dominant. At the beginning of this experiment the vegetation was dominated by *Urochloa* species with some small patches of spontaneous herbs (Figure 1-A). The surrounding area is predominantly rural, with farms intended for livestock and agriculture, as well as many natural forest fragments distant 500 m or less.

A total of 28 plots were established, corresponding to seven brushwood treatments (different sizes) and four replications each, organized according to a randomized blocks design, totaling 648 m^2 (Figure 1-B). The distance between treatments ranged from 5 to 10 m. In all plots, except for the control, the grasses were cut, leaving the residue on the soil. All brushwood were formed by eight layers of plant residues and reached approximately height of 0.7 m. The layers were arranged in the following order: small logs of wood and peach palm; leafless bamboo sticks; leafless bamboo sticks in reverse direction to the previous layer; bamboo sticks with leaves in reverse direction to the previous layer; palm leaves; bamboo sticks with leaves; dry branches and palm leaves.

Regarding the size of the plots, we adopted that the minimum width of 4 m (CARPANEZZI; NICODEMO, 2009) would be enough for the establishment of natural regeneration in the center of the brushwood, before the *Urochloa* spp. reoccupation were too inhibitory. Based on this, all brushwood treatments had a fixed length of 6 m and a variable length of 1 to 6 m, comprising values below and above 4 m (premise). The treatments were: 6 x 1 m (6 m^2), 6 x 2 m (12 m^2), 6 x 3 m (18 m^2), 6 x 4 m (24 m^2), 6 x 5 m (30 m^2), 6 x 6 m (36 m^2) (Figure 1-C a H) and control treatment without brushwood of 6 x 6 m (36 m^2).

All individual shrubs and trees found were counted and identified at 4, 8, 12, 18 and 24 months after the experiment installation. Woody species were classified by their origin as native or exotic (LISTA... 2016); by their seed dispersal syndrome in zoochorous,

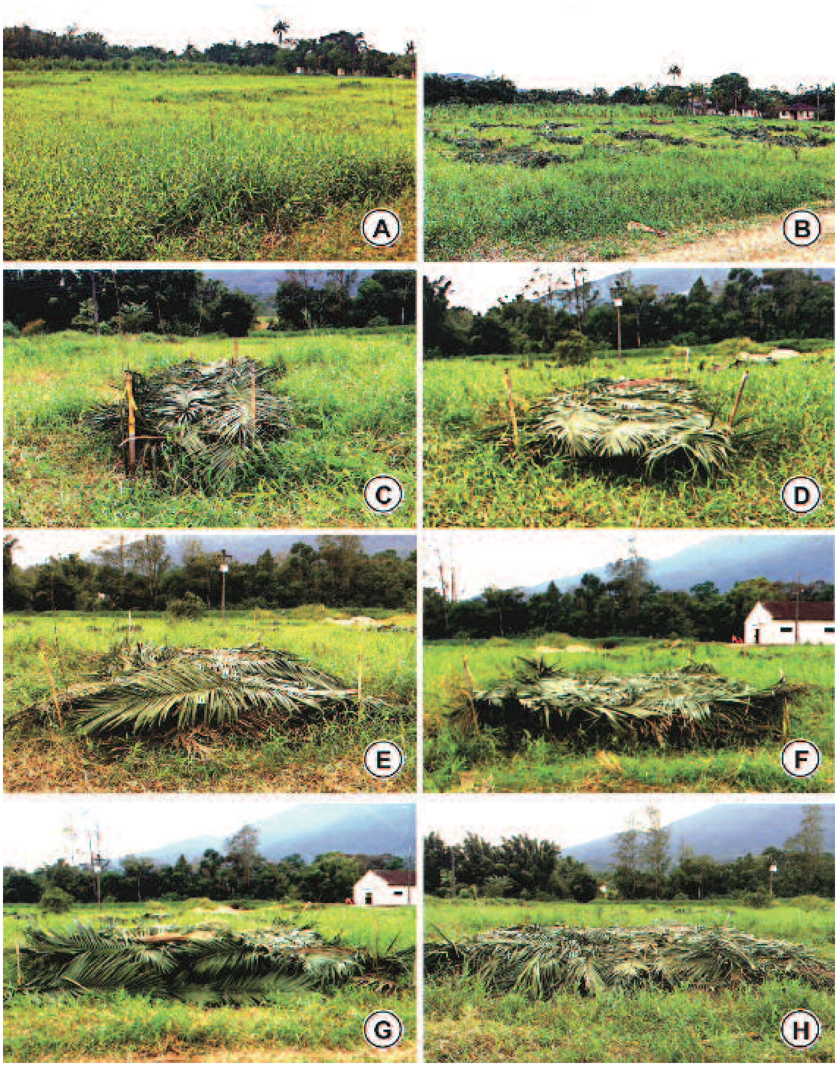

FIGURE 1 Beginning of the experiment: A - area before treatments; B - area after treatments; C - brushwood of 6 x 1 m; D - brushwood of 6 x 2 m; E - brushwood of 6 x 3 m; F - brushwood of 6 x 4 m; G - brushwood of 6 x 5 m; H - brushwood of 6 x 6 m.

anemochorous and autochorous (VAN DER PIJL, 1982) and; by successional categories as pioneer, secondary and climax (BUDOWSKI, 1965). A visual estimation of ground cover percentage using a template of 0.50 x 0.50 m (quadrant) was made for herbaceous species, sequentially allocated over two subplots, one in the center of the fixed size of the plot (6 m), resulting in 12 sample points or quadrants, and other in the center of its variable size according to treatment (1 to 6 m). Three classes were considered: grasses (Poaceae family), other herbs and the absence of vegetation. The herbaceous species were identified and classified according to their origin as native or subspontaneous (ruderais, cosmopolitan and exotic invaders) (LISTA… 2016), and dispersal syndrome (VAN DER PIJL, 1982). We also analyzed the percentage of reoccupation of grasses from the edges of the plots towards the center, which is represented by the quadrants (Q) from 1 to 6, with Q3 and Q4 being the center of the plot, and Q1 and Q6 the edges of the plot. Only the assessment data from the center of the fixed size of the plot (6 m) was used to estimate the reoccupation of forages.

The homogeneity of variances was evaluated by Cochran test and, subsequently, the data were subjected to variance analysis, in a split-plot design. The main plots corresponded to the seven brushwood treatments and the subplots to the five evaluated periods (4, 8, 12, 18 and 24 months). In situations of statistical significance ($p<0.05$), the average of the studied variables were submitted to Tukey test at 5% of probability.

RESULTS

At the end of the trial period there were 124 woody plants in the set of plots (648 m^2). Five species were identified, belonging to the Asteraceae, Fabaceae, Onagraceae and Verbenaceae families, highlighting *Vernonanthura beyrichii*, which represented 73% of individuals (Table 1).

There were no statistical differences between assessments for the density of woody plants. Although all treatments showed reduced abundances of woody. Plots of 6 x 1 m showed the lowest density (Table 2).

An increase in the percentage of poaceae cover was observed in all treatments after eight months of evaluation; no statistical significance between plot sizes was observed (Table 3). The high percentage of poaceae from the second evaluation, higher than 70%, highlights the quick recolonization by grasses within the plots.

Regarding coverage by other herbaceous species (Table 3), there was no significant difference between treatments and assessments, and the percentages remained below 30%. The lack of vegetation was significant only at the first evaluation for all sizes of brushwood (higher than 40%), followed by an intense and permanent fall.

According to the percentage of grasses cover, represented by the quadrants (Q) from 1 to 6, coverage did not differ among the quadrants of all treatments after eight months (Figure 2).

TABLE 2 Parameters estimates of the omnidirectional and cross semivariograms Vol = volume, Exp = Exponential.

Treatments	Tree and Shrub					
	Months					Averages
	4	8	12	18	24	
6 x 1	0.04	0.00	0.00	0.00	0.04	0.02 b
6 x 2	0.13	0.13	0.35	0.31	0.25	0.23 a
6 x 3	0.33	0.21	0.22	0.25	0.08	0.22 ab
6 x 4	0.14	0.11	0.11	0.09	0.15	0.12 ab
6 x 5	0.18	0.16	0.17	0.28	0.23	0.19 ab
6 x 6	0.07	0.08	0.13	0.14	0.16	0.12 ab
C	0.06	0.08	0.13	0.05	0.14	0.09 ab
Averages	0.14 A	0.11 A	0.15 A	0.15 A	0.15 A	
CV(a) = 140.07% / CV(b) = 99.03%						

CV = variation coefficient values for treatments (a) and assessments (b). Averages followed by the same lower case letter in the column and capital letter in the line do not differ between them for Tukey test at 5% probability.

TABLE 1 Parameters estimates of the omnidirectional and cross semivariograms Vol = volume, Exp = Exponential.

Family	Scientific name	NI	LF	LC	OR	SC	DS	6x1	6x2	6x3	6x4	6x5	6x6	C
Asteraceae	-	103												
Asteraceae	Chromolaena maximilianii (Schrad. ex DC.) R.M.King & H.Rob.	13	Shrub	Pe	Na	Pi	An	0	6	0	2	0	0	5
Asteraceae	Vernonanthura beyrichii Less. H.Rob.	90	Shrub	-	Na	Pi	An	1	8	12	10	25	21	14
Fabaceae	Mimosa bimucronata (DC.) Kuntze.	14	Tree	-	Na	Pi	Au	0	1	3	1	4	2	2
Onagraceae	Ludwigia octovalvis (Jacq.) P.H.Raven	5	Shrub	-	Na	Pi	Au	0	0	1	1	0	2	1
Verbenaceae	Stachytarpheta cayennensis (Rich.) Vahl	2	Shrub	-	Na	Pi	An	0	0	0	0	0	2	0
Total NI	-	124	-	-	-	-	-	1	15	16	14	29	27	22
Total species	-	5	-	-	-	-	-	1	3	3	4	2	4	4

Na = native, Pi = pioneer, Ane = anemochoric, Aut = autochorous.

TABLE 3 Percentage of coverage by grasses (Poaceae), spontaneous herbs and lack of vegetation along the assessments. Treatments: 6 x 1, 6 x 2, 6 x 3, 6 x 4, 6 x 5, 6 x 6 m and control (C).

Grasses (%)						
Treatments	4 months	8 months	12 months	18 months	24 months	Averages
6 x 1	47.40 b B	85.83 a A	82.97 a A	83.59 a A	90.52 a A	78.06
6 x 2	25.00 bc B	79.38 a A	84.53 a A	73.91 a A	78.28 a A	68.22
6 x 3	29.64 bc B	78.07 a A	81.51 a A	84.22 a A	83.96 a A	71.48
6 x 4	27.37 bc B	81.72 a A	84.45 a A	84.58 a A	91.82 a A	73.99
6 x 5	19.68 c B	74.16 a A	75.47 a A	77.47 a A	88.90 a A	67.13
6 x 6	28.18 bc B	68.02 a B	79.32 a AB	82.50 a AB	86.04 a A	68.81
C	77.40 a A	88.85 a A	90.00 a A	79.06 a A	84.96 a A	84.05
Averages	36.38	79.43	82.61	80.76	86.35	
CV(a) = 26,24% / CV(b) = 10,31%						
Spontaneous Herbs (%)						
Treatments	4 months	8 months	12 months	18 months	24 months	Averages
6 x 1	9.95	10.68	16.93	16.20	9.48	12.65 a
6 x 2	15.05	15.57	15.36	25.63	21.72	18.67 a
6 x 3	19.11	16.35	15.00	13.54	12.66	15.33 a
6 x 4	15.70	12.84	15.29	15.26	8.18	13.45 a
6 x 5	16.24	20.82	21.30	18.27	10.69	17.46 a
6 x 6	15.36	24.74	19.32	16.98	14.01	18.08 a
C	18.44	9.06	10.00	20.94	15.04	14.70 a
Averages	15.69 A	15.72 A	16.17 A	18.12 A	13.11 A	
CV(a) = 69,42% / CV(b) = 50,13%						
Lack of Vegetation (%)						
Treatments	4 months	8 months	12 months	18 months	24 months	Averages
6 x 1	42.66	3.49	0.10	0.21	0.00	9.29
6 x 2	59.95	5.05	0.10	0.47	0.00	13.11
6 x 3	51.25	5.57	3.54	2.24	3.07	13.14
6 x 4	56.93	5.44	0.26	0.16	0.00	12.56
6 x 5	64.08	5.02	3.23	4.26	0.42	15.40
6 x 6	56.46	7.24	1.41	0.52	0.21	13.17
C	4.17	2.08	0.00	0.00	0.00	1.25
Averages	47.93	4.84	1.24	1.12	0.53	
CV(a) = 88.40% / CV(b) = 51.88%						

CV = variation coefficient of treatments (a) and assessments (b). Averages followed by the same lower case letter in the column and capital letter in the line do not differ between them according to Tukey´s test at 5% probability.

A number of 31 herbaceous species were identified in all the plots, most of them are native (71%), they belong to 18 families, being Asteraceae, Cyperaceae, Poaceae and Rubiaceae the highest in species richness (Table 4). The most frequent species were *Urochloa subquadripara*, *Urochloa decumbens*, *Mikania micranta*, *Commelina difusa*, *Melothria pendula*, *Ipomea cairica*, *Desmodium triflorum* and *Sphagneticola trilobata*. According to the dispersal syndromes, anemochory was the dominant (45% of the species). Autochory and zoochory were present in 23% and 26% of the identified species, respectively; for 6% of the species the dispersal syndrome was not determined (Table 4).

DISCUSSION

The small number of woody plants two years after the treatments application (Table 1) highlights a possible failure in the germination of seeds in the seed bank, of those arriving in the seed rain or in the establishment of seedlings, as well as the permanence of limiting conditions for natural regeneration. In pastures, factors such as a reduction of soil fertility (GRISCOM; ASHTON, 2011), loss of edaphic structure (RASIAH et al., 2004), the absence of seed dispersers (GÜNTER et al., 2007), predation (COLE, 2009) and unsuitable microclimate for seed germination and/or seedling establishment (MAZA-VILLALOBOS et al., 2011) are limiting the colonization by species capable of competing with dominant grasses.

Under these conditions, few species are able to establish themselves, albeit in a limited way. An example is *Vernonanthura beyrichii* that, despite being the woody plant with the highest number of individuals in all sizes of brushwood and one of the first to emerge, was not able to contribute significantly to natural regeneration. The greatest abundance of *Vernonanthura beyrichii* has been observed at the beginning of regeneration in abandoned pastures (CHEUNG et al., 2009; SCHEER et al., 2009), which is attributed to its facility to colonize open areas, clearings and edges of fragments (ANTONELLI FILHO

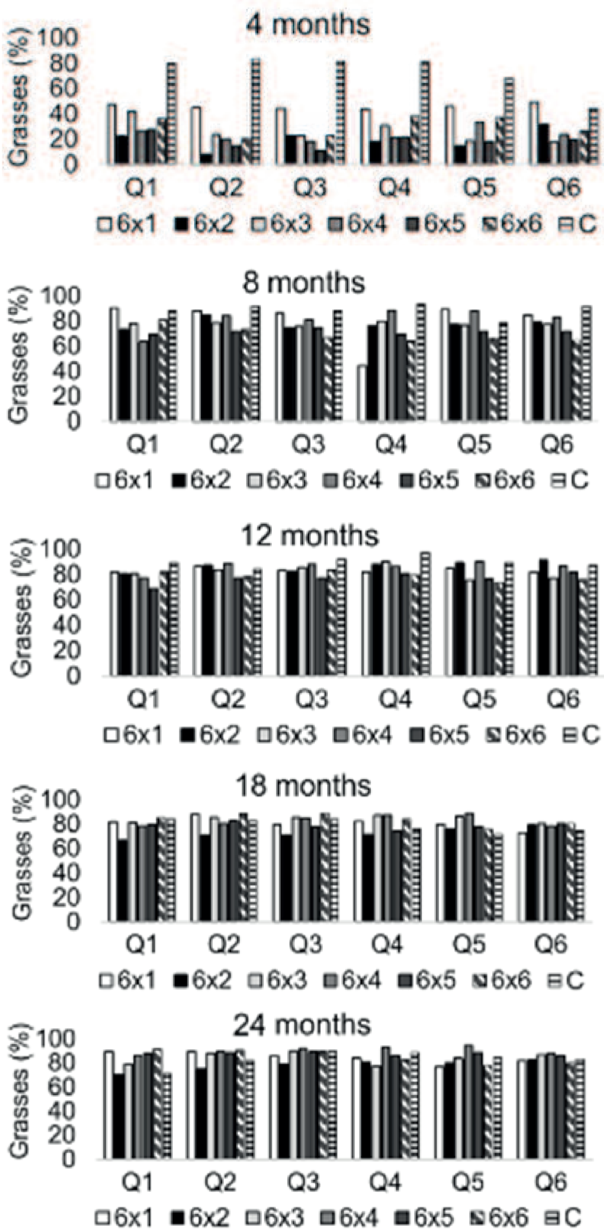

FIGURE 2 Percentage of grasses (Poaceae) cover from the edges of the plots towards the center, according to the quadrants (Q) from 1 to 6, with Q3 and Q4, the central quadrants. Treatments: 6 x 1, 6 x 2, 6 x 3, 6 x 4, 6 x 5, 6 x 6 m and control (C).

et al., 2012). Because of these characteristics, it should be considered an important shrub at the beginning of succession (BAYLÃO JÚNIOR et al., 2011), and its selection (CARPANEZZI; NICODEMO, 2009), as a tool to facilitate the establishment of other species.

The brushwood, regardless of the applied size, did not provide favorable conditions for the establishment of woody species, which is demonstrated by their low values (Table 2) and by the absence of significant differences

TABLE 4 Herbaceous species registered throughout the assessments, in all treatments. Seed dispersal syndromes (DS), origin (OR).

Family/scientific name	DS	OR
Araliaceae		
Hydrocotyle leucocephala Cham. & Schltdl.	Ane	Nat
Asteraceae		
Hyptis pectinata (L.) Poit.	Aut	Nat
Mikania micrantha Kunth	Ane	Nat
Sphagneticola trilobata (L.) Pruski	Ane	Sub
Begoniaceae		
Begonia cucullata Willd.	Ane	Nat
Caryphyllaceae		
Drymaria cordata (L.) Willd. ex Roem. & Schult.	Zoo	Sub
Commelinaceae		
Commelina diffusa Burm.	Zoo	Nat
Tripogandra diuretica (Mart.) Handlos	Zoo	Nat
Convolvulaceae		
Ipomoea cairica (L.) Sweet	Ane	Sub
Ipomoea sp.	Ane	Nat
Cucurbitaceae		
Melothria pendula L.	Zoo	Nat
Cyperaceae		
Cyperus mundtii (Nees) Kunth	nc	Nat
Kyllinga brevifolia Rottb.	Ane	Nat
Scleria melaleuca Rchb. ex Schltdl. & Cham.	Zoo	Nat
Fabaceae		
Desmodium triflorum (L.) DC.	Zoo	Sub
Mimosa pudica L.	Ane	Nat
Hypoxidaceae		
Hypoxis decumbens L.	Aut	Nat
Lamiaceae		
Hyptis brevipes Poit.	Aut	Nat
Mesosphaerum suaveolens (L.) Kuntze	Aut	Nat
Linderniaceae		
Lindernia diffusa (L.) Wettst.	Ane	Nat
Lythraceae		
Cuphea carthagenensis (Jacq.) J.Macbr.	Ane	Nat
Malvaceae		
Sida rhombifolia L.	Ane	Nat
Oxalidaceae		
Oxalis debilis Kunth	Aut	Nat
Poaceae		
Eragrostis ciliaris (L.) R.Br.	Ane	Sub
Urochloa decumbens (Stapf) R.D.Webster	Ane	Sub
Urochloa humidicola (Rendle) Morrone & Zuloaga	Ane	Sub
Urochloa subquadripara (Trin.) R.D.Webster	Ane	Sub
Rubiaceae		
Borreria latifolia (Aubl.) K.Schum.	Aut	Nat
Borreria palustris (Cham. & Schltdl.) Bacigalupo & E. L. Cabral.	Aut	Nat
Diodia saponariifolia (Cham. & Schltdl.) K.Schum.	Ane	Nat
Umbelliferae		
Centella asiatica (L.) Urban	Zoo	Sub

Ane = anemochory, Aut = autochory, Zoo = zoochory, nc = not classified, Nat = native, Sub = subspontaneous.

between treatments. The brushwood itself is a thick layer of litter and can have adverse effects on the natural regeneration process (FACELLI; PICKETT, 1991). In pastures, the shading exerted by the brushwood aims to weaken the inhibiting grasses, allowing the seeds contained in the soil to germinate and grow as the materials decompose (MARCUZZO et al., 2013). However, the brushwood was not effective to stem the growth of grasses (Table 3). Even the largest size treatment (6 x 6 m) did not show less reinvasion by grasses at the end of the experiment (Figure 2). The forage plant dominant in the area, *Urochloa subquadripara,* presents intense vegetative propagation (Seed formation is uncommon) (KISSMANN; GROTH, 1997), which allows rapid growth, besides other attributes such as high photosynthetic efficiency and high competitive force (CHEUNG et al., 2009; POZZOBON et al., 2010; SOUZA et al., 2012), inhibiting native species colonization.

The need to constantly intervene on grasses for good results in woody plant establishment was verified in similar works with nucleation (MIRANDA NETO et al., 2010; LEAL FILHO et al., 2013; BIERAS et al., 2015). Recruitment of native plants into abandoned pastures is limited by many factors. The dense biomass of grasses reduces the amount of light on the soil, preventing germination in positive photoblastic seeds (REINHART et al., 2006). Soil compaction, as it often occurs in degraded pastures (LANZANOVA, 2007), reduces the incorporation of seeds into the seed bank and affects processes such as gas exchange and germination (SUN; DICKINSON, 1996). A lower soil aeration in humid places, such as the study area, may compromise the necessary supply of oxygen for germination, growth and development of the seedling (LEADEM et al., 1997). For seedlings that can exceed pasture height, if environmental conditions reduce leaf evapotranspiration due to the high relative humidity of the air, high tissue temperatures can be lethal to the plant (ARAÚJO; DEMINICIS, 2009).

It is therefore noted that recommending practices proclaimed as nucleation techniques requires clear prescriptions for its application to culminate with the establishment of desirable species. At least the link with the land use, the size of the pile, materials and associated cultural traits should be considered in the case of brushwood. Aspects such as height and density should be adjusted to control the invasion of grasses and, at the same time, allow the development of seedlings inside it. Materials with fast decomposition quickly provide nutrients to the ground, but disappear soon, having a temporary effect on seedlings recruitment. High and thickened brushwood promote more shading on grasses, but they can also prevent the germination and/or establishment of desirable species.

The equality of coverage by grasses between the edges and the center of the plots, from the second evaluation onwards, is consistent with the low percentages for other herbaceous in all treatments, due to the competition by forage plants. The predominance of herbaceous with abiotic dispersal was expected (Table 4), being a common aspect in pastures. Anemochory and autochory are typical of open environments, since the visitation of seed dispersers is less common or non-existent (GÜNTER et al., 2007; TOMAZI et al., 2010). As a result, most species found correspond to plants already present in pasture.

Despite the low density of woody plants and other herbaceous species verified in this investigation, some research carried out in areas with and without natural regeneration inhibitor species have reported changes caused by brushwood, in the structure and abundance of arthropods and an increase in the concentration of soil organic matter (ALVES; PINHEIRO, 2013; VERGÍLIO et al., 2013). However, the traditional measurement of the success of ecological restoration is based on the effectiveness of plant succession.

CONCLUSIONS

Regardless the size of the brushwood applied in the pasture, the mechanisms of natural regeneration remain limited by the presence of exotic grasses *Urochloa* spp. The brushwood, as a single technique of nucleation, is inefficient to control the growth of grasses from the edges of plots and, like pile of residues, hinders the establishment of native woody species.

For the forest restoration by natural regeneration in pastures, actions should be combined to overcome dispersive and competitive barriers, without which the seeds from the native species are unlikely to survive. Practices that do not cause local elimination of forage plants of the genus *Urochloa*, which is necessary for the creation of a favorable seedbed, tend to fail in ecological restoration by natural regeneration in abandoned pastures.

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