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# Stock And Litter Decomposition In Different Vegetation Types And Eucalypt Plantations In The Cerrado Region, Brazil

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**ABSTRACT**

Background: The litter stock and decomposition are influenced by climate variables and have been considered an important nutrient input in tropical areas. Objective: This research aimed to evaluate the stock, litter decomposition and their interactions with the microclimate variables in two Cerrado phytophysionomies (Cerrado *stricto sensu* and Gallery Forest) and a *Eucalyptus urophylla x E. grandis hybrid* population in Água Limpa Farm of the University of Brasilia in Distrito Federal, Brazil. Results: The annual averages of the litter stock were 8.05 t $ha^{-1}$ in the Cerrado *stricto sensu*, 11.41 t $ha^{-1}$ for the Gallery Forest and 10.96 t $ha^{-1}$ for the *Eucalyptus urophylla x E. grandis* hybrid population. It was verified seasonal patterns in litter stock: for the Cerrado *stricto sensu* were obtained the greater stock and there was no significant difference between the dry and the rainy season; for the Gallery Forest, the litter stock was superior during the rainy season and the opposite result was observed to *Eucalyptus* population. Concerning the decomposition rate, the constants k were 0.0007, 0.0007 and 0.0009, with decomposition time of 50 % of the material estimated in 2.7, 2.7 and 2.1 years to Cerrado *stricto sensu*, Gallery Forest and *Eucalyptus urophylla x E. grandis* hybrid population, respectively. Conclusion: The litter presented a low decomposition rate, especially for natural habitats (Cerrado *sensu stricto* and Forest Gallery), which suggests that the floristic composition in these environments is more recalcitrant and, as a consequence, it would take almost three years for this biomass be transformed and/or mineralized in 50 %.

## INTRODUCTION

Brazilian territory has around 53.56 % of its area covered by natural forests and 0.84 % by planted forests (ABRAF, 2013). Eucalypt plantation is the most important forest plantation in Brazil, covering approximately 6.5 million hectares and is the source of almost 5 million direct and indirect employments (ABRAF, 2013). Another important forest formation is Cerrado *stricto sensu* area, composed by natural forest and savannah formation and located under the tropical climate. Several vegetation types are components of the Cerrado *stricto sensu*, (Silva *et al*., 2007). Among those types, on the Cerrado *stricto sensu* predominates tree and shrub vegetation, covering from 20 % to 50 % of the biome. Another important region vegetation type is the Gallery Forest, which is a forestry formation along of watercourse. This type of vegetation presents an important ecologic and hydrological function, since it protects the boarders of the rivers, avoiding slitting and assures the



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quality and quantity of water on the rivers (Ribeiro and Walter, 2008). Both natural and/or planted forests are important source of forest products in Brazil and their sustainability is related to the litter stock and nutrient cycling across the years (Campos *et al*., 2008).

In this context, during their growth, trees from different vegetation perform an important role on organic matter production formed in the soil by litter stock and decomposition (Richard *et al*., 2010) The litter consists of organic residues deposited on the soil, mainly originated by plant, such as leaves, twigs, flowers, branches, seed, bark, fruits, and a lower proportion of animal origin materials such as animal carcass dead and excrements. The litter stock may vary during the year, in function of vegetation type, stand age, water precipitation, temperature, topography, latitude, besides other factors (Vieira *et al*., 2009; Vieira and Schumacher, 2011; Skorupa *et al*., 2015; Villa *et al*., 2016). Furthermore, it also improves the physical capacity of the soil and contributes with the nutrient cycling, being the main route for nutrient input in the soil (Cunha-Neto *et al*., 2013).

According to Schumacher *et al*. (2013), the litter production is associated with the material of deposition over the forest soils and its stock is directly connected to the production and inversely proportional to the decomposition rates. The litter decomposition is resulted by the breakdown of organic material deposed over the soil and occurs due the leaching, fragmentation and chemical change of these materials. Some factors, such as the climate, litter quality and microorganism composition are needed for this process. The soil microorganisms are responsible for the degradation of the organic material and normally use 5 % of the soil volume available (Samai and Benslama, 2015). The temperature and the precipitation are the climatic factors that most affect the rotten process and may vary between the regions.

As the litter stock and decomposition are important factor that contributes to nutrient cycling and it may vary in function of vegetation types, this research aimed to evaluate the litter stock accumulated over the soil and litter decomposition, as well as their relationship with climatic variables in two vegetation types (Cerrado *stricto sensu* and Gallery Forest) and in a *Eucalyptus urophylla x E. grandis* hybrid population in Água Limpa Farm, in Distrito Federal, Brazil.

## MATERIAL AND METHODS

***Study area:***

The study region is located at the Água Limpa Farm (ALF) of the University of Brasilia, under the coordinates 15º31'S and 47º42'W, Distrito Federal. The ALF area measures 4,340 ha, from which 2,340 ha (54 % of the total area) are designed for preservation, 800 ha to conservation (18 %) and 1,200 ha (28 %) to agriculture and forestry production. The climate in the region is Aw, according to the Köppen classification, with two seasons: dry, between May and September, and rainy, between October and April. The annual temperature average is 20.62 °C and the annual rainfall is 1,526.82 mm, according to data provided by the Climatological Automatic Station from University of Brasilia (Figure 1). According to the Brazilian System for Soil Classification, the soil is classified as Dystrophic Red Latosol (Oxisol).

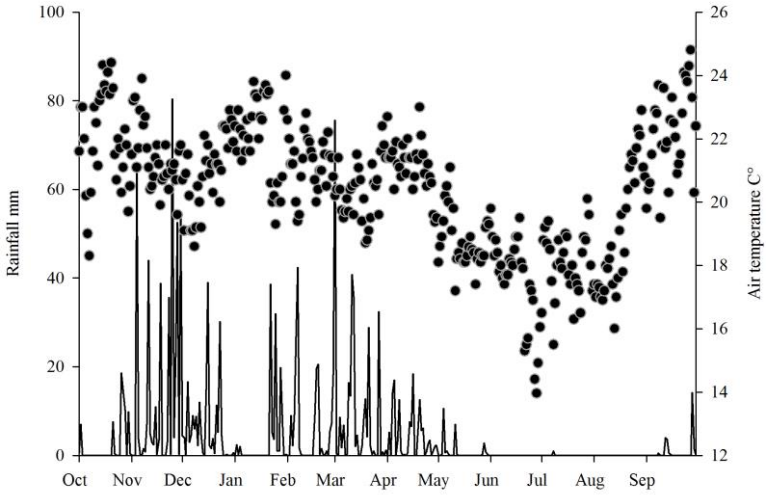


**Fig. 1:** Rainfall (mm) and air temperature (Cº) from October 2014 to October 2015 at the Água Limpa Farm, Distrito Federal, Brazil.

The study was conducted in areas of Cerrado *stricto sensu*, Gallery Forest and I224 clonal population (hybrid of *Eucalyptus urophylla* x *Eucalyptus grandis)*. The seedlings were planted spacing 3 x 2 m on December 2010. To the soil prepare was used a trencher agriculture without side fins, using only subsoiling rod (40-50 cm). The fertilizer applied was: 100 g of superphosphate + 100 g NPK (4-30-16), after 30 days of planting the topdressing was carried out with 100g of NPK (20-0-20).

***Data sampling:***

To quantify the litter stock on each area four samples were collected. Therefore, it was used as a collector a square metallic template measuring 0.5 x 0.5 m (0.25 m²), randomly disposed with a minimum distance of 5 m between the plots sampled. The sampling was performed in places where topographical conditions were similar and a minimum distance of 20 m of roads and firebreaks, to avoid possible board effects over the litter stock.

Regarding the litter decomposition analysis, in each area were distributed randomly on the forest floor 144 litterbags made with nylon mesh of 2 mm 20 x 30 cm and containing 20 g of dry litter collected from the own area study. Every month, the litter stock and four litterbags were collected from each area during the period October 2014 to September 2015

The litter was packaged in a labeled paper bags, sealed and taken to the laboratory to obtain the wet weight of the material and then were dried for 72 hours in a forced circulation air oven at 65 ° C until constant weight.. Subsequently, the dry biomass of the stock was extrapolated for hectare.

***Data processing:***

The dry weight stock of the litter were determined (t $ha^{-1}$) from the averages of the four sample plots of each studied area, Data from the litter stock were submitted to the analysis of variance (ANOVA), the averages of the data were compared by the Tukey test ($p < 0.01$), using the SISVAR software, 5.6 version aiming to identify possible differences between the environments for the dry and rainy seasons.

To calculate the decomposition rate (k), we used the following exponential model, as described by Olson (1963):

$$y = A\ e^{-kt}$$

In which, y is the remaining dry weight quantity (g), after a period, where t represents time in days; A is the constant, k is the decomposition constant, both obtained by the Sigma Plot Software for Windows 12.5, through data regarding litter contained in the litterbags during 360 days. Another useful characteristic to evaluate the plant material decomposition is the half-life time which express the necessary period for half of the waste to decompose or half of the nutrients contained in these wastes to be liberated. According to Rezende *et al*. (1999) it is possible to calculate the half-life period by the equation:

$$t_{1/2} = \ln (2) / k = 0{,}693/k$$

In which $t_{1/2}$ is the half-life period of the remaining matter; ln (2) is the constant value; and k is the decomposition constant.

Data regarding litter biomass (stocked and decomposed) and climate data from the region, provided by the Automatic Climatologic Station from University of Brasilia (average temperature and rainfall), and the moisture content were submitted to the Pearson Correlation statistical analysis, according to the Student "t" test, aiming to find associations between those variables.

## RESULTS AND DISCUSSION

***Litter stock:***

The monthly stock of litter was higher on August of 2015, for the Cerrado *stricto sensu* and the eucalypt plantation, with 10.95 and 14.45 t $ha^{-1}$, respectively. For the Gallery Forest, the higher litter stock occurred on November of 2014, with 17.33 t $ha^{-1}$ (Figure 2). When comparing the litter stock among the three vegetation types, the Gallery Forest was statistically higher during the four rainy months (Figure 1). This result may be a reflection of the beginning of the growing season, period in which the foliage of the tree canopy is renewed and that coincides with the rainy season, resulting in a higher soil water availability and high temperatures. Vital *et al*. (2004), in study in a riparian forest found the peak of litter production during the rainy period and according to these authors it might be due the stronger winds, which contributed to the deposition of this material.

During the dry season, in July and September 2015, higher litter stock was observed at the *Eucalyptus* stand compared to the other areas. It might be due to reduction of transpiration rate by leaves fall after decreased of water availability.

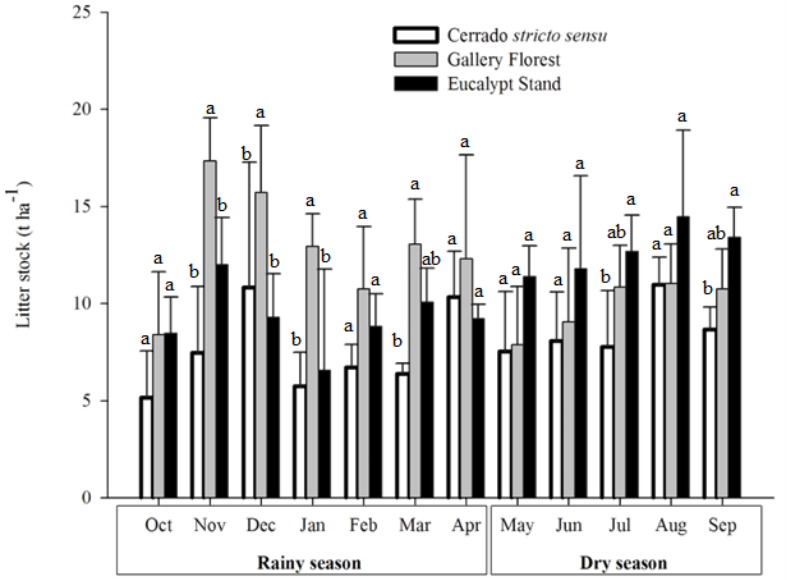


**Fig. 2:** Litter stock from October 2014 to September 2015 in three vegetation types on Água Limpa Farm, Distrito Federal, Brazil. (Standard deviation = 4 replicates)

Concerning to seasonality, the litter stock in Cerrado *stricto sensu* showed no significant differences between the rainy and dry season, with 7.5 and 8.59 t $ha^{-1}$, respectively. In the Gallery Forest, the largest stock occurred in the rainy season with 12.92 t $ha^{-1}$, statistically different from the dry season with 9.90 t $ha^{-1}$. The opposite occurred for *Eucalyptus* population, with 9.20 and 12.73 t $ha^{-1}$, during the rainy and dry season, respectively.

The litter stock observed on the Cerrado *stricto sensu* area in this study was above from what was verified in a Cerrado *stricto sensu* area in Curvelo - Minas Gerais, Brazil - (6.46 t $ha^{-1}$) (Paiva *et al*., 2011). In a Cerrado *stricto sensu* area in Brasilia, Ribeiro *et al*. (2011) verified a litter stock of 7.11 t $ha^{-1}$, similar to the results found in this research. Maman *et al*. (2007) on the southwest of Mato Grosso, observed that the litter stock of the Cerrado *stricto sensu* was 9.41 t $ha^{-1}$ and 12.89 t $ha^{-1}$ on the Gallery Forest. Those differences between the litter stocks might be related to the floristic composition on the Cerrado *stricto sensu* formations. According to Ribeiro and Walter (2008), on Forest Galleries, the arboreal extract height varies from 20 m to 30 m, where the crowns overlap each other, providing tree coverage of 70 % to 95 % of area. As for the Typical Cerrado *stricto sensu*, tree and shrubs predominate the phytophysionomy, with heights around 3 m to 6 m and arboreal coverage from 20 % to 50 % of area.

As for planted forest, in a investigation conducted to assess cycling and nutrient balance in the same stand of *Eucalyptus* in the Água Limpa Farm, Gatto *et al*. (2014) found a litter stock of 7.18 t $ha^{-1}$. The difference of 3,78 $tha^{-1}$ found in this study, when compared to the study of the same author may be related to the change of time for which the data were collected.

The annual litter stock verified on the eucalypt stand was lower than that observed in other studies. In *Eucalyptus grandis* x E. *urophylla* populations at the age of six year-old and arrangement of 3 m x 2 m in Paraíba do Sul river valley, Melos *et al*. (2010), found 11.9 t $ha^{-1}$ of litter stock. Cunha-Neto *et al*. (2013) found litter stock of 8.83 t $ha^{-1}$ in Atlantic Forest for trees at the age of 3,5 years and 13.42 t $ha^{-1}$ for trees at the age of 4,5 years in *Eucalyptus grandis* stand with a 2,5 m x 2 m arrangement, in Além Paraíba town, Minas Gerais, Brazil. It's important noteworthy that all those previous cited studies were conducted in areas with higher precipitation regime compared to this research area.

***Litter decomposition:***

The exponential mathematical model that describes the litter decomposition on the studied areas of the Água Limpa Farm is presented on Figure 3. The exponential curves of the decomposition (y) have adjusted well to the model, presenting regression index of 0.97 in natural forests and 0.95 in the planted forest ($p<0.01$) (Figure 3). The rate of decomposition (k) were 0.0007, 0.0007 and 0.0009 and the time of 50 % of the decay of the material estimated in 2.7, 2.7 and 2.1 years for the Cerrado *stricto sensu*, Gallery Forest and *Eucalyptus* stand, respectively.

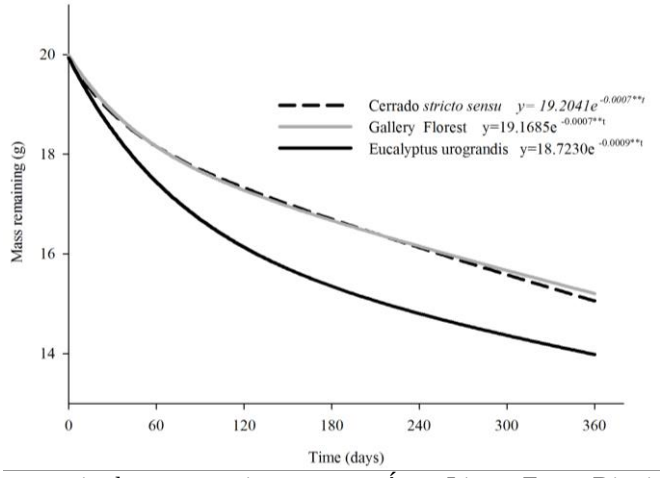


**Fig. 3:** Litter decomposition curve in three vegetation types on Água Limpa Farm, Distrito Federal, Brazil.

Usually, the value of the litter stock is not only resulted by the accumulation of litter on the forest soil (Figure 2), but also to the low decomposition constant (Figure 3). Under different conditions, those formations vary from 0.002 to 0.74 (Cianciaruso *et al*., 2006; Diniz *et al*., 2011; Viera *et al*., 2014).

The remaining mass of litter, after 360 days of sampling, were 76.4 %, 76.75 % and 69.9 % for Cerrado *stricto sensu*, Gallery Forest and *Eucalyptus* stand, respectively. Giácomo *et al*. (2012) found a decomposition rate of 16 % and 19.7 % in a Cerrado *stricto sensu* area during 30 and 60 days, and by the end of the experiment, at 210 days, the remaining mass was 44.5 %. The higher loss of mass, in this case, might be related to the size of the litterbag mash, which, due to its greater size, provides a better interaction with the soil fauna. Valenti *et al*. (2008) found similar results in a Cerrado *sensu stricto* area with a remaining mass of 78 %, by the end of twelve months.

The Forest Gallery, as well as the Cerrado *stricto sensu*, presented a greater remaining mass (Figure 3), different result found by Maman *et al*. (2007) while studying a Forest Gallery in Mato Groso (Brazil) southwest region for 11 months. These authors observed a mass loss of 22 % at the end of the period. On the eucalypt population, the remaining mass was above the mass found by Vieira *et al*. (2014) in an experiment developed in a hybrid plantation of *Eucalyptus urophylla* x *Eucalyptus globulus* in Eldorado do Sul (Rio Grande do Sul, Brazil), in which 63 % of remaining mass was found in a year period.

Around 50 % of the litter was decomposed on the first trimester of the year (Figure 3). During the release on the initial phases of the decomposition, occurs the fragmentation of the particles caused by physical agents, soil biota which releases more soluble compounds such as sugars, starches and proteins, which are quickly used by the decomposers. After this period, most of the recalcitrant structures composed by lignin, cellulose, fats, tannins and waxes, such as ribs and petiole, decrease the speed of the decomposition (Viera *et al*., 2014; Carvalho *et al*., 2009). Costa *et al*. (2005), while studying the nutrient release from leaf litter in *Eucalyptus grandis* populations, reported that greater litter decomposition, around 30 %, also occurred on the first trimester of the year.

The *Eucalyptus* stand plantation showed the most adverse behavior related to the decomposition rate and it might be due the structure composition of the leaves. Silva *et al*. (2014) found a small loss of mass on native plantations, which might be associated to the higher amounts of lignin, an organic fraction more resistant. As for the planted forests, the greater mass loss occurred on the first two months of the year, on the other months, the value observed became stable.

***Relation between the litter and the climatic variables:***

The Pearson correlations between the climatic variables (temperature, rainfall and moisture content) and the litter (stock and decomposition) on the environments studied are described on Table 1. Generally, there were 61 % of significant correlations at 1% and 5% of probability. The Cerrado *stricto sensu* presented more correlations between the variables, for litter stock and decomposition. Regarding to the litter stock, negative correlation was found between water content and rainfall in this ecosystem. Campos *et al*.(2008) and Cianciaruso *et al*.(2006) also observed significant and negative correlations between the litter availableness and the rainfall, in a mesophytic forest and Cerrado *stricto sensu* in Uberlandia (Minas Gerais, Brazil) and in a different type of Cerrado (Cerradão) in the region of Jatai. Similar to this study, Santos-Neto *et al*. (2015), while analyzing *Pterogyne nitens* and *Eucalyptus urophylla* in the Southwest region of Bahia (Brazil), verified a positive correlation between the rainfall and amount of litter deposed.

**Table 1:** Pearson's correlation among the climatic variables in relation to litter stock and decomposition in three physiognomies on Água Limpa Farm, Distrito Federal, Brazil.

| Litter Stock | Moisture content | Air Temperature | Rainfall |
|---|---|---|---|
| Cerrado *stricto sensu* | -0.279** | 0.056 ns | -0.381* |
| Gallery Forest | 0.365* | 0.276 ns | 0.027 ns |
| *Eucalyptus* | -0.155 ns | 0.046 ns | -0.403* |
| Mass remaining | Moisture content | Air Temperature | Rainfall |
| Cerrado *stricto sensu* | 0.385* | 0.369* | 0.741* |
| Gallery Forest | 0.323** | 0.200 ns | 0.708* |
| *Eucalyptus* | 0.086 ns | 0.423* | 0.739* |

ns = non-significant, * significant at 5%; ** significant at 1 % of probability by the Student t test.

We could observed in this experiment that several factors can affect the quantity of shoot tree parts that form the litter, as climatic factor, litter quality and microorganism composition. Selle (2007) affirms that despite the climatic factors, the production and deposition of litter might be also related to the soil proprieties and the genetic characteristics of the species. On a wider scale, the vegetal biomass is determined by the distribution of the rainfalls, which influences the availableness of water on the soil. According to Vital *et al*. (2004), the seasonal variation of the litter deposition is a result of interaction between vegetation and the climate. Viera and Schumacher (2010) also verified a high correlation between the rainfall and litter quantity deposed during a study performed in a eucalypt stand.

Furthermore, the litter decomposition might be explained by the rainfall interactions, as observed on Table 1. On the natural environments (Cerrado *sensu stricto* and Forest Gallery), there was a significant correlation between the decomposition and moisture content and it might be explained by the capacity of the forests to retain water on the soil. Miranda Neto *et al*. (2015) observed in a mined area submitted to the restoration process that the highest decomposition rate occurs during the rainy period.

The air temperature also influenced the decomposition of the Cerrado *sensu stricto* and eucalypt plantation. It's important noteworthy that the fact of the air temperature was not correlated to the Gallery Forest might be explained by the arboreal extract, where the crowns are overlapped. Such coverage is responsible for maintaining the elevated relative humidity inside the forest, even during the dryer season of the year (Ribeiro and Walter, 2008).

Nowadays, there are still scarce information about litter stock and decomposition rate and the relationship between climate variables and vegetation types in Brazil. Our study confirms that the seasonality has great influence on the litter decomposition process, mainly the precipitation rate, in both natural and planted forests.

### *Conclusion*

From the studied areas, the higher annual litter stock (11.41 t $ha^{-1}$) was found on the Forest Gallery. Regarding seasonality, in the Forest Gallery, the largest stock occurred in the rainy season and for the *Eucalyptus* stand was higher during the dry season. In the Cerrado *sensu stricto* the seasonal pattern did not present significant differences between seasons. Still concerning the seasonality, with the exception of the Gallery Forest, the litter stock had negative correlation with rainfall and moisture content.

The litter presented a low decomposition rate, especially for natural habitats (Cerrado *sensu stricto* and Forest Gallery), which suggests that the floristic composition in these environments is more recalcitrant and, as a consequence, it would take almost three years for this biomass be transformed and/or mineralized in 50 %.

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## REFERENCES

Associação Brasileira de produtores de Florestas Plantadas (ABRAF). Anuário estatístico da ABRAF – ano base 2013. Brasília, Brasil.

Campos, E.H., R.R. Alves, D.S. Serato, G.S.S.C. Rodrigues and S.C. Rodrigues, 2008. Acúmulo de serrapilheira em fragmentos de Mata Mesofítica e Cerrado *stricto senso* em Uberlândia-MG. Sociedade & Natureza, 20(1): 189-203.

Carvalho, W., L. Canilha, A. Ferraz and A.M.F. Milagres, 2009. Uma visão sobre a estrutura, composição e biodegradação da madeira. Química Nova, 32(8): 2191-2195.

Cianciaruso, M.V., J.S.R. Pires, W.B.C. Delitti and E.F.L.P. Silva, 2006. Produção de serapilheira e decomposição do material foliar em um cerradão na Estação Ecológica de Jataí, município de Luiz Antônio, SP, Brasil. Acta Botanica Brasilica, 20(1): 49-59.

Costa, G.S., A.C. Gama-Rodrigue and G.M. Cunha, 2005. Decomposição e liberação de nutrientes da serapilheira foliar em povoamentos de *Eucalyptus grandis* no norte Fluminense. Revista Árvore, 29(4): 563-570.

Cunha-Neto, F.V., P.S.S. Leles, M.G. Pereira, V.G.H. Bellumath and J.M. Alonso, 2013. Acúmulo e decomposição da serapilheira em quatro formações florestais. Ciência Florestal, 23(3): 379-387.

Diniz, A.R., M.G. Pereira and A. Loss, 2011. Aporte de material decíduo e nutrientes para o solo em plantio de eucalipto e floresta secundária. Pesquisa Florestal Brasileira, 31(65): 19-26.

Gatto, A., A.P. Bussinger, F.C. Ribeiro, G.B. Azevedo, M.C. Bueno, M.M. Monteiro and P.F. Souza, 2014. Ciclagem e balanço de nutrientes no sistema solo-planta em um plantio de *Eucalyptus sp.* no Distrito Federal. Revista Brasileira de Ciência do Solo, 38: 879-887.

Giácomo, R.G., M.G. Pereira and D.L. Machado, 2012. Aporte e decomposição de serapilheira em áreas de Cerradão e Mata Mesofítica na Estação Ecológica de Pirapitinga-MG. Ciência Florestal, 22(4): 669-680.

Luizão, F.J., 2007. Ciclos de nutrientes na Amazônia: respostas às mudanças ambientais e climáticas. Ciência e Cultura, 59(3): 31-36.

Maman, A.P., C.J. Silva, E.M. Sguarezi and M.E. Bleich, 2007. Produção e acúmulo de serapilheira e decomposição foliar em mata de galeria e cerradão no sudeste do Mato Grosso. Revista de Ciência e Agro-Ambientais, Alta-Floresta, 5(1): 71-84.

Melos, A.R., A.M. Sato and A.L. Coelho-Netto, 2010. Produção, Estoque e Retenção Hídrica da Serrapilheira em Encosta Sob Plantio de Híbridos de *Eucalyptus Urophylla* e *Eucalyptus Grandis*: Médio Vale do Rio Paraíba do Sul. Anuário do Instituto de Geociências – UFRJ, 33(2): 66-73.

Miranda Neto, A., S.V. Martins, K.A. Silva, A.T. Lopes and R.A. Demolinari, 2015. Litter production and leaf litter decomposition in mined area in restoration process in southeast Brazil. Australian Journal of Basic and Applied Sciences, 9(23): 321-327.

Paiva, A.O., A.V. Rezende and R.S. Pereira, 2011. Estoque de carbono em Cerrado sensu stricto do Distrito Federal. Revista Árvore, 35: 527-538.

Rezende, C.P., R.B. Cantarutti, J.M. Braga, J.A. Gomide, J.M. Pereira, E. Ferreira, R. Tarré, R. Macedo, B.J.R. Alves, S. Urquiaga, G. Cadisch, K.E. Giller and R.M. Boddey, 1999. Litter deposition and disappearance in *Brachiaria* pastures in the Atlantic Forest region of the south of Bahia, Brazil. Nutrient cycling in Agroecosystems, 54: 99-112.

Ribeiro, J.F and B.M.T. Walter, 2008. As principais fitofisionomias do Bioma Cerrado In: Sano, M.S., S.P. Almeida, Cerrado: Ecologia e Flora. Embrapa, Brasília - DF, pp: 153-212.

Ribeiro, S.C., L. Fehrmann, C.P.B. Soares, L.A.G. Jacovine, C. Kleinn and R.O. Gaspar, 2011. Above and belowground biomass in a Brazilian Cerrado. Forest Ecology and Management, 262: 491-499.

Richards, A.E., D.I. Forrester, J. Bauhus and M. Scherer-Lorenzen, 2010. The influence of mixed tree plantations on the nutrition of individual species. Tree Physiology, 30: 1192-208.

Samai, I and M. Benslama, 2015. Study of soil-vegetation relationships of the forest Ouled Bechih (Souk Ahras ). Advances in Environmental Biology, 9(18): 82-90.

Santos-Neto, A.P., P.A.B. Barreto, E.F. Gama-Rodrigues, A.B. Novaes and A. De Paula, 2015. Produção de serapilheira em floresta estacional semidecidual e em plantios de *Pterogyne nitens Tul.* e *Eucalyptus urophylla* S. T. Blake no sudoeste da Bahia. Ciência Florestal, 25(3): 633-643.

Schumacher, M.V., R.S. Corrêa, M. Viera and E.F. Araújo, 2013. Produção e decomposição de serapilheira em um povoamento de *Eucalyptus urophylla x Eucalyptus globulus maidenii.* Revista Cerne, 19: 501-508.

Selle, G.L., 2007. Ciclagem de nutrientes em ecossistemas florestais. Revista Bioscience Journal, 23(4): 29-39.

Silva, C.J., F.A. Lobo, M.E. Bleich and L. Sanches, 2009. Contribuição de folhas na formação da serrapilheira e no retorno de nutrientes em floresta de transição no norte de mato Grosso. Acta Amazonica, 39(3): 591-600.

Silva, C.J., L. Sanches, M.E. Bleich, F.A. Lobo and J.S. Nogueira, 2007. Produção de serapilheira no cerrado e Floresta de Transição Amazônia-Cerrado do Centro-Oeste brasileiro. Acta Amazonica, 37(4): 543-548.

Silva, H.F., P.A.B. Barreto, G.T.O. Souza, G.B. Azevedo, E.F. Gama-Rodrigues and F.G.R.B. Oliveira, 2014. Decomposição de serapilheira foliar em três sistemas florestais no Sudoeste da Bahia. Revista Brasileira de Biociências, 12(3): 164-172.

Skorupa, A.L.A., N.F. Barros and J.L. Neves, 2015. Forest litter decomposition as affected by eucalyptus stand age decomposição de serapilheira florestal. Revista Árvore, Viçosa, 39: 1055-1064.

Olson, J.S., 1963. Energy storage and the balance of producers and decomposers in ecological systems. Ecology, 44(2): 322-331.

Valenti, M.W., M.V. Cianciaruso and M.A. Batalha, 2008. Seasonality of litterfall and leaf decomposition in a cerrado site. Brazilian Journal of Biology, 68(3): 459-465.

Schumacher, M.V. and E.F. Araújo, 2014. Disponibilização de nutrientes via decomposição da serapilheira foliar em um plantio de *Eucalyptus urophylla x Eucalyptus globulus.* Revista Floresta e Ambiente, 21: 307-315.

Viera, M., M.V. Schumacher and D.M. Bonacina, 2011. Biomassa e nutrientes removidos no primeiro desbaste de um povoamento de *Pinus taeda* L. em Cambará do Sul, RS. Revista Árvore, Viçosa, 35(3): 371-379.

Viera, M. and M.V. Schumacher, 2010. Deposição de serapilheira e de macronutrientes em um povoamento de acácia-negra (*Acacia mearnsii* De Wild.) no Rio Grande do Sul. Ciência Florestal, 20: 225-233.

Vieira, J.A.G., M.B. Texeira, A. Loss, E. Lima and E. Zonta, 2009. E. Produção de Serapilheira e Retorno de Nutrientes ao Solo pela Espécie Eucalyptus urograndis. Revista Brasileira de Agroecologia, Porto Alegre, 4(2): 40-43.

Vital, A.R.T., I.A. Guerrini, W.K. Franken and R.C.B. Fonseca, 2004. Produção de serrapilheira e ciclagem de nutrientes de uma floresta estacional semidecidual em zona ripária. Revista Árvore, 28(6): 793-800.